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Hypertext: Improved Capability for
Shipboard Naval Messages

by

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Hypertext: Improved Capability for Shipboard Naval Messages

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Lieutenant, United States Navy
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requirements for the degree of

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ABSTRACT

This thesis demonstrates how a new software technology, hypertext, can provide capabilities which will improve the handling and utilization of naval messages on board ship. The current process for shipboard message handling involves the use of communications equipment, computers, duplication machines, and such manual operations as control, distribution, annotation, filing and search. An Automated Message Handling System based on the hypertext concept offers opportunities to enhance each of these operations. The enhancements will come from performing required tasks in a more organized manner while requiring less dependence on paper and providing a far more efficient and effective means for using naval messages as an information resource. Developments in computer technology make it feasible to implement such a system on currently available, low cost, commercial hardware. This thesis includes a logical design for a hypertext message system developed using rapid prototyping techniques.

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I. INTRODUCTION

The efficient use of information on board ship is increasingly important at a time when the Navy faces an expanding mission and fewer available resources. The capability to properly process and use information is a necessity given the current environment. Messages represent an especially vital shipboard information resource. They are the Navy's most frequently used means of communication, playing a key role in the conduct of virtually all administrative and operational business. The value of the information they contain requires that adequate mechanisms and procedures exist to manage their handling and facilitate their use.

The current volume of message traffic and the requirements of the users for processing information indicate that the present paper-based system may have reached the limits of its usefulness. This thesis investigates current trends toward the automation of shipboard information systems and provides a systems analysis and design for an improved message handling system. The proposed system is based on the principles of hypertext, a relatively new software technology for handling information. Hypertext offers opportunities to enhance user access to information while eliminating the need to distribute and store paper copies of messages.

A. BACKGROUND

The current process for shipboard message handling involves the use of communications equipment, computers, duplication machines, and such manual operations as control, distribution, annotation, filing and search. The

present methods used to review, store and retrieve naval messages fail to take advantage of currently available information technology. The processing and distribution of messages to end users require extensive duplication efforts, greatly contributing to the proliferation of paper on board ship and wasting numerous man-hours. Elaborate personal file systems must be maintained by users to guarantee their ability to access information when needed. These paper-based systems allow each message copy to be stored in only one file folder at a time. In order to locate and retrieve messages through a variety of different identifiers, users must file redundant copies under several different category headings. The present system makes no provisions for rapidly accessing cited references or keeping track of those messages requiring responses. Failure to locate such information when needed often results in the commission of errors that could have otherwise been avoided. The current system also lacks a mechanism for assisting message drafters to use existing information in the generation of new messages. Recent advancements in information technology provide feasible alternatives capable of addressing these problems.

B. OBJECTIVES

The Navy is already aware that computers can be used to automate the distribution, storage and handling of shipboard message traffic. Some automated systems have already been developed to improve these procedures and others are being investigated. Most of the current emphasis on automating paper-based shipboard information systems has concentrated on getting rid of paper and replacing it with data stored in an electronic format. This helps to address some of the problems, but leaves many unanswered. The objective of

this study is to contribute to ongoing Navy efforts to improve shipboard message handling procedures. A systems analysis and design are presented for a new computer-based information system that confronts the problems with the current procedures and provides enhanced capabilities for processing and using messages.

C. SCOPE

The analysis and design of an improved system for handling the distribution, storage, retrieval, and use of naval messages is the focal point for this thesis. The mechanisms and features of hypertext are used to support the user requirements and design issues developed during the systems analysis. The concentration of the design has been on "what" the system must do to meet the needs of the user as opposed to "how" the system should be physically implemented. The hardware requirements for such a system are not addressed.

The design methodology utilized rapid prototyping techniques to develop the system features and user interface. Prototypes have been built using Guide and HyperCard, currently available hypertext products for IBM compatible and Macintosh personal computers, and NextStep, a user interface and development environment for the NeXT computer. The purpose of the prototyping effort is to demonstrate the features and capabilities of hypertext as they apply to the message handling system; a complete working model of the system has not been developed.

D. ORGANIZATION OF STUDY

1. The "Paperless" Ship Initiative

Chapter II presents the reader with background on the "paperless" ship initiative, a program created in 1986 to reduce the Navy's requirements for paper-based documentation aboard naval ships. This chapter identifies problems with the Navy's current message handling procedures, discusses current automation efforts, and presents opportunities for further improvements.

2. Systems Analysis and Methodology

Chapter III provides a systems analysis for an improved message handling system. This chapter identifies the user requirements for the system and lays out a set of principles to guide the design efforts. Three alternative solutions for implementing the system are identified and evaluated. The use of rapid prototyping as a methodology for designing the system is also presented.

3. The Vision and Mechanisms of Hypertext

Chapter IV provides an in-depth discussion of hypertext, the method that was chosen as the best design alternative during the systems analysis phase. This chapter introduces the reader to the background and terminology of hypertext, explaining the building blocks of this technology as well as the more complex issues of composition and access.

4. Automated Message Handling System Design

Chapter V adapts the mechanisms and features of hypertext introduced in Chapter IV to the user requirements and design principles developed during the systems analysis. A logical design for the Automated

Message Handling System (AMHS) is presented. The design takes a functional approach, providing detailed descriptions of message receipt, distribution, review, filing and retrieval, and message generation.

5. Conclusions and Recommendations

The final chapter discusses the conclusions and recommendations of the study. The benefits of using hypertext for improving shipboard message handling procedures are reviewed, and recommendations for further research are identified.

II. THE "PAPERLESS" SHIP INITIATIVE

The Navy is currently placing a great deal of emphasis on reducing the quantities of paper found on board its warships. In late 1986 Vice Admiral Joseph Metcalf III, deputy chief of naval operations for surface warfare, created the "paperless" ship initiative under the direction of the Space and Naval Warfare Systems Command. The goal of this initiative is to reduce the requirements for paper-based technical, reference, and mission critical documentation aboard naval ships. To accomplish this goal the Navy has directed its attention towards the storage of information in a digital format. Various storage media are being investigated to determine their suitability for the task, including optical disk technology. (Ruff, 1988, p. 157)

There are two major motivations behind the initiative. The first is that paper consumes space and weight aboard ship which could be better utilized for the storage of additional weapons systems and ammunition. The second is concerned with the inordinate amount of time required by ship's officers and crew to manage and use the immense volumes of paper aboard ship. It is this second issue that is perhaps the most crucial because the time spent handling paper takes away from that available for the practice of "warfighting" skills. The Navy is aware that advances in information technology present viable options for reducing paper requirements and improving information management.

A. PLAN FOR ACHIEVING THE "PAPERLESS" SHIP

A three phase plan has been implemented to achieve a “paperless” ship by the early 1990's. Phase I, completed in May 1987, consisted of a data collection survey to establish a baseline of the volume of paper currently held aboard United States Naval warships. Phase II involved a shipboard demonstration of optical disk technology which resulted in favorable user feedback regarding its potential for use aboard ship. Phase III, currently in progress, incorporates the recommendations from Phases I and II and places a prototype system on four ships. (Ruff, 1988, p. 158)

The results of the Phase I study proposed a wide range of technical and reference publications, messages, ship's drawings, forms, reports, and logs for automation. The study identified considerable weights and volumes of paper on all units surveyed. Surface ships were found to contain the greatest amounts, though significant quantities were also recorded aboard a submarine and at an air squadron. A newly commissioned Aegis cruiser was found to contain 35.9 tons of paper and associated containers and a frigate some 20.6 tons. (Ruff, 1988, p. 158)

B. CATEGORIES OF PAPER

The paper found aboard ships can be broken down into three general categories: reference materials, working materials, and stock material. Reference materials include such items as technical manuals, charts, engineering drawings, and operating procedures. This type of material is generally produced by an activity outside the ship and distributed to a large number of units. It is updated on an infrequent basis and the ship will typically maintain several copies to ensure easy access. The second category,

working materials, are used in the performance of daily administrative and operational assignments. They include such items as messages, administrative files and records, and logs and record forms. This information must be easily accessible at all times because it is used on a daily basis and represents the most current and up to date data available. The third category is stock materials. These include the blank paper, forms, and log books which will be used to support the need for working materials. (Chickering, 1988, p. 227)

Reference materials represented the largest portion of the information identified during the Phase I survey. They accounted for some fifty-five percent of the paper while the working documents and stock materials were recorded at twenty-five and twenty percent respectively. (MacDonald, 1987, p. 15) Because of these figures and the relatively static nature of reference materials, this category has received the greatest attention thus far as an area for potential reductions.

C. AN EVALUATION OF PAPER

Before examining alternatives for reducing the quantities of paper-based information on board ship it is necessary to examine the advantages and disadvantages of this medium.

1. Advantages

"One of the most beneficial traits of paper-based documentation is the great degree of intimacy the user is able to have with the material it contains." Distributing information in a paper format allows the user to establish a personal domain over the material. This sense of ownership and control

results in a more effective transfer of information to the user. (Chickering and Qualls, 1989, p. 63)

Another advantage deals with availability. Information stored in paper form is always available, without being dependent on the operation of additional hardware and software to retrieve it. Paper is also easily distributed. It can be delivered or carried to any part of the ship without requiring the presence of a terminal to use it. The paper format allows a document to be easily customized to meet user needs. The user can take a paper document and make annotations in the margins and highlight portions of its text so that it will convey greater meaning when the information is referred to at a later date. (Van Dam, 1988, p. 894)

2. Disadvantages

There are also many disadvantages to using paper-based information systems, especially on board ship. The two factors that drew early attention from Vice Admiral Metcalf are the weight and volume of space that is occupied by paper. But these are by no means the extent of the problems with paper.

Information stored in paper form must be indexed and filed so that it may be accessed at a later time. The nature of the medium requires this activity to be performed manually. This can be a time consuming and frustrating task, but one that is very important to a paper-based system. The accessibility of the information to the user is a direct function of how well these files are organized and maintained. To solve some of these access and timeliness problems users tend to file redundant copies under different

identifiers, further complicating the issue of paper proliferation. (Chickering, 1988, pp. 227-228.)

The paper format limits the ability of multiple users to access documents simultaneously. (Chickering and Qualls, 1989, p. 63) Since paper does not lend itself to being shared very well, an interested user will typically borrow the document and make a copy of his own. In any modern organization information is viewed as an important resource, the Navy is no exception. This perspective creates an environment where workers seek to obtain and control information. The result for many organizations, including the Navy, is the building of personal paper filing systems, or databases.

In addition to the significant weight and storage space required by paper, this medium also presents a serious fire hazard aboard ship. The Navy considers fire to be the single most dangerous threat to the safety of its ships. Paper could easily fuel a fire and would most certainly be destroyed by any extinguishing efforts. Paper also tends to deteriorate. This most commonly occurs with age, but in the machinery filled environments on board ship it is not uncommon for paper materials to come in contact with water, fuel, oils, greases, and other substances which cause it to degrade more rapidly. The maintenance of paper systems is a very costly operation. Copier machines, toner and paper are significant operating expenses for modern warships. (Chickering, 1988, p. 228) Elaborate destruction methods for classified documents further add to the cost of paper-based systems.

D. MESSAGE STORAGE AND HANDLING REQUIREMENTS

Though somewhat overshadowed by reference materials, naval messages make significant contributions to the volume of paper aboard ship. Current distribution procedures involve taking messages that are received in electronic form, printing them, duplicating the appropriate number of copies and then finally routing these copies to the individual users. It is particularly interesting that in this age of modern computers a large portion of the Navy is still converting electronically transmitted messages to paper for dissemination and use.

The volume of messages received and distribution requirements will vary from ship to ship. Some of the factors that tend to influence volume include the size of the ship, its operating requirements, and whether or not a staff is embarked. Typically an aircraft carrier will receive the greatest number of messages of all the ships in a battle group. The ratio between the number of messages processed by the aircraft carrier and the smaller units is approximately 10:1. Table 1 presents statistics compiled for an aircraft carrier with embarked staff during a recent deployment to provide some estimates of how many messages are actually handled on board ship.

Each message is checked against distribution lists to determine how many copies must be made and who will receive them. Table 2 depicts the distribution requirements for messages received by the staff embarked on the aircraft carrier.

TABLE 1. DAILY MESSAGE TRAFFIC VOLUMES FOR DEPLOYED CARRIER AND EMBARKED STAFF

For Entire Ship	Send	245
	Receive	1166
For Staff Only	Send	24
	Receive	460

TABLE 2. STAFF MESSAGE TRAFFIC DISTRIBUTION REQUIREMENTS

Classification	# Messages/ Day	# Copies/ Message	# Copies/ Day
Top Secret	9	1	9
Secret	55	9	495
Confidential	299	17	5083
Unclassified	97	17	1649
Average total number of copies for staff			7236

If each of these messages were only a single sheet in length, the paper required to duplicate the staff message traffic alone for the six month deployment would consume 1,302,480 sheets. This is equivalent to 260.5 cases of copier paper which would occupy 130.25 cubic feet and weigh 5,210 pounds.

This paper originally exists as stock material, blank copier paper, and is converted to working material as messages are duplicated and distributed. Not all of these copies will be stored, in fact a good portion will be destroyed, but the current system necessitates that this paper be carried on board to satisfy the requirements for distributing information.

The electronic storage of information creates opportunities to reduce paper requirements in favor of storage formats that would occupy far less space and weight. A single 5-1/4 inch diskette, of the type commonly used for IBM compatible personal computers, can store over 150 pages of data in one-tenth the space required to store the equivalent amount of information in paper form. Technological developments have created other forms of digital storage, such as high density magnetic and optical disks that are capable of storing even greater quantities of information in a smaller space. (Chickering, 1988, p. 230) Figure 1 demonstrates how three different electronic storage formats could each handle the task of storing the number of messages distributed by the carrier group staff during their six month deployment. Use of any one of these formats could significantly reduce the need to carry such large quantities of stock material. The tremendous storage capabilities made possible by optical disk technology make it an especially attractive alternative.

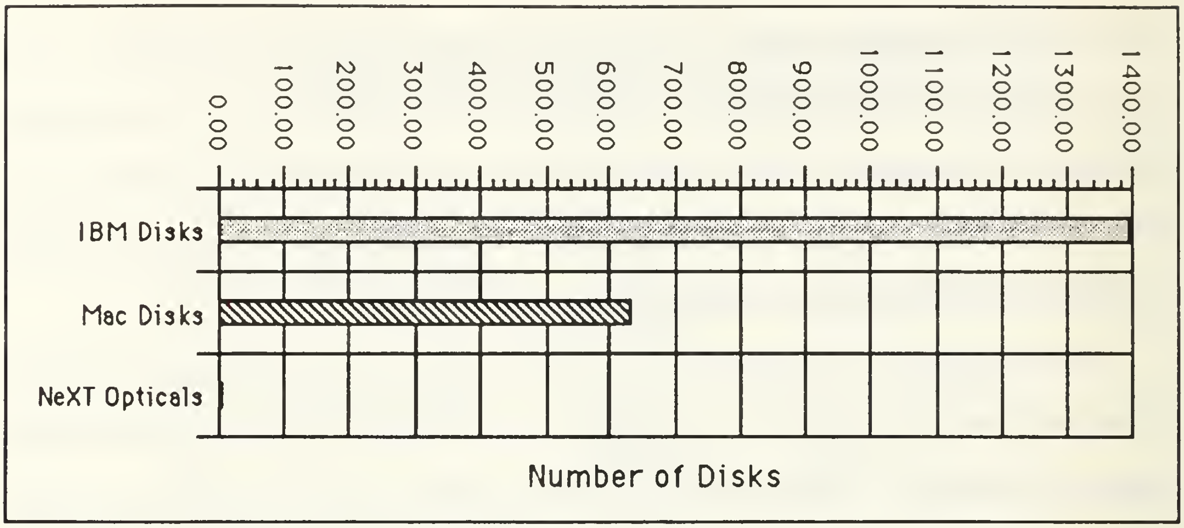

Figure 1. Electronic Storage Capacities

E. THE NEED FOR AUTOMATED MESSAGE HANDLING

There is a clear need to develop paperless information systems to improve the Navy's current methods for handling message traffic. Formal channels of communication have traditionally relied heavily on printed documents as a means of distributing information. Current volumes of messages and the requirements for processing information seem to indicate that the limits on the usefulness of paper for distributing, storing and retrieving information have been reached. Technological breakthroughs over the last several decades are raising questions concerning the importance and necessity of paper in the information systems of the next century. The solution most often suggested today is an electronic alternative to paper. (Lancaster, 1978, p. 1)

Naval messages are a prime candidate for use in an electronic format instead of a paper-based system. The electronic transmission of message traffic allows for easy capture at the destination point in a digital format. This provides the Navy with the opportunity to design and develop a system that will receive messages and distribute them in an electronic form for on-line review.

1. Current Automation Efforts

Much of the current emphasis on automating paper-based shipboard information systems has concentrated on getting rid of the paper and replacing it with data stored in an electronic format. The "paperless" ship initiative has shown a great deal of interest in optical storage technology as an alternative to paper. Research has been performed regarding the mastering of reference material on optical disk CD-ROM (Compact Disk – Read Only Memory) which then could be supplied to the ship for use. Early results indicate that optical disks offer a practical alternative for the storage of large amounts of information in a small space. (Chickering and Qualls, 1989, p. 61)

Optical technology has come to the forefront because of the immense volumes of data that can be held on a single optical disk. However, not all optical disks are alike. Several different categories of optical storage media have been developed, all offering significant increases over removable magnetic disk technology. The most prominent thus far has been CD-ROM. Current 1989 technology enables over 550 megabytes of data to be stored on a single CD-ROM disk. This is the equivalent of 1500 standard 5.25" floppy disks, 700 Macintosh 3.5" disks, thirty 20-megabyte hard disks, or some

270,000 pages of printed text. This format allows a user to access information from a previously mastered disk, but does not permit any information to be added to or removed from the disk. WORM (Write Once Read Many) is another form of optical disk which permits the user to write to and read from the disk but not to erase any of the information once it is stored. The WORM disk is presently capable of holding either 200 or 400 megabytes, depending on whether or not information is stored on a single side or on both sides. (Zilber, 1988, p. 158)

The latest introduction to the family of optical storage devices is the magneto-optical disk. This format is a significant breakthrough for mass storage technology because it offers full read/write/erase functionality in a high density removable disk. This technology was introduced in the late part of 1988 as part of the NeXT computer. The capacity of the disk is 256 megabytes. (Webster, 1989, pp. 111-112) As was illustrated previously, two of these disks (currently priced at $50 apiece) would be capable of holding the equivalent number of pages required to distribute an embarked carrier group staff's traffic for six months.

Storing documents in a digital format on high density storage media addresses many of the issues behind the first motivation for the "paperless" ship initiative—that paper consumes space and weight aboard ship which could be better utilized for the storage of additional weapons systems and ammunition. It also opens up many new possibilities for tackling the second, more important motivation: reducing the inordinate amount of time required by ship's officers and crew to manage and use the immense volumes of paper aboard ship. Documents stored in a digital format present users and

information resource managers with opportunities to redesign and improve the way they use information.

2. The Present State of Automating Messages

The Navy has made some significant efforts to improve its procedures for handling messages aboard ship. Computers are already employed aboard ship to assist in some of the functions required for processing message traffic.

a. The NAVMACS System

The Naval Modular Automated Communications System (NAVMACS) serves as the standard afloat automated telecommunications system, but despite the name the system is still far from being fully automated. The purpose of the NAVMACS system is to perform the necessary processing required to terminate and originate a ship's General Service message traffic. NAVMACS is actually a family of system configurations that vary in age, size, and performance capabilities from ship to ship. Many of the older versions still utilize paper tape as the method of entry for outgoing messages and printed copy for delivery of incoming messages. (NAVTASC, 1989)

The latest, most sophisticated, version is the NAVMACS V5 system. This version, installed only on carriers and flag configured ships, offers entry and delivery of messages through remotely connected display and printer terminals. The NAVMACS V5 can be configured with up to 16 terminals spread throughout the ship. The system is designed to process message traffic, both incoming and outgoing, but is not an archive and retrieval device. System storage is small, consisting of two redundant disks

each capable of holding only 2 megabytes of data. The system is rated at 5,000 messages per day with current usage at 3,000 messages or less. Messages are typically stored on the system for less than a day. They are then backed up to a tape system where they are maintained for a period of up to 60 days. (Telephone conversation, Mr. Dick Demello, SPAWARS, 22 March 1989) This system is still essentially paper-based and offers little in the way of added functional benefits to the user.

The Navy is already aware that its methods, especially on ships with older configurations, require extensive manpower and paper requirements, are error prone, and require constant supervision. Automatic Data Processing technologies are being examined for ways to improve the efficiencies of message handling operations. (NAVTASC, 1989)

b. *The Personal Computer Message Terminal*

The Personal Computer Message Terminal (PCMT) couples Personal Computer (PC) hardware equipment with Navy developed software systems to further automate message processing functions. This program is still in the developmental stages. The system is being proposed to interface with the NAVMACS system, allowing the two systems to work in tandem to improve afloat message handling procedures. The objective of the PCMT project is to develop a system that could be installed on board ship to help automate the NAVMACS message entry and delivery functions. (NAVTASC, 1989)

The PCMT will write incoming messages received from the NAVMACS system to disk storage and assign a message accountability number that can be used for transaction logging or later retrieval. The PCMT

will utilize the Local Routing List/Distribution Blocks passed from NAV-MACS to determine which users will be designated as receivers of a message. The system as planned would enable messages to be sent to a printer, written to diskette, or routed through a security device to a Office Automation System (OAS) or Automated Information System (AIS). The PCMT design states that the OAS can be operated as a stand alone workstation or as a local area network connecting a group of workstations. The AIS described in the PCMT design might involve an interface with existing systems such as SNAP. COMNAVTELCOM has been tasked with testing software developed by industry and government agencies to interface with the PCMT. (NAVTASC, 1989)

CINCLANTFLT is currently operating an office automation system to assist in the processing of narrative record communications. This is a shore based system which automates the distribution of messages by using an off-the-shelf electronic mail software package, All-In-1. (NAVTASC, 1988, pp. 1-3) The CINCLANTFLT Office Automation System (COAS) has made significant strides towards improving the utilization of naval messages.

c. *The Defense Message System*

Another automation effort currently being pursued by the Defense Communications Agency (DCA) is the Defense Message System (DMS). A working group was formed in 1988 to assess the future of the Department of Defense's messaging systems. The goal of the group is to formulate a target architecture based on available, or reasonably achievable technology, that meets the requirements of transferring information from originator to receiver while cutting operating costs and staffing. Secondary

objectives include improving the system's functionality, survivability, and security. (DCA, 1988, p. 1-1)

The major emphasis of DMS appears to be shore-based commands, but the efforts of this program are likely to impact future shipboard communication as well. The current components of the DMS are the Automatic Digital Network (AUTODIN) and electronic mail on the DoD Internet. AUTODIN is a worldwide computerized, general purpose communications system that transmits both narrative and data traffic by secure means. The present DoD Internet is composed of the Defense Data Network (DDN) and associated Local Area Networks (LANs). (DCA, 1988, p. 1-2) The target architecture for DMS calls for the evolution of the system to Integrated Services Digital Network (ISDN) compatibility to allow use of the ISDN as the DMS transport mechanism. (DCA, 1988, p. 2-2)

The DMS working group has identified a list of requirements to guide the DoD's progress towards improving its message communication system. These requirements are stated in general terms to allow the services flexibility in developing solutions that meet their individual needs. Many of the requirements deal with the delivery of information from the originator to the receiver, but DMS also begins to address how to improve the ways in which information can be used at the receiving end. The DMS Target Architecture and Implementation Strategy clearly lays out a requirement for the system to support the storing of messages after delivery and to provide a means of retrieval to allow for readdressal, retransmission, and such automated handling functions as archival, analysis, and incorporation of segments into future messages. (DCA, 1988, p. 1-6)

3. Opportunities for Further Improvements

Modern technology is being applied to naval telecommunications with the purpose of improving current procedures for handling messages. Efforts thus far have concentrated on replacing the present printed media with an electronic format. But simply digitizing messages will do little to help users interface with the information. The current challenge is to develop systems that are capable of taking full advantage of this format, making the information contained in message traffic more accessible and easier to use.

Recent computer hardware and software advances have permitted the development of systems which allow users to gain greater control over their information resources. These systems are revolutionizing the way people are performing their jobs, making their use of information more efficient and effective. The changes that are taking place may also impact the quality of decisions being made by providing users quicker and easier access to relevant data. Systems such as database, electronic mail, and hypertext can be used for a wide range of applications to support the information requirements of users. The combination of these systems with the immense storage capabilities of optical disks offers exciting possibilities for improving the utilization of information aboard ship. (Chickering and Qualls, 1989, p. 61) The application of information retrieval technology need not be restricted to reference materials but can also be applied advantageously to working materials such as naval messages.

III. SYSTEMS ANALYSIS AND METHODOLOGY

The previous chapter identified the problems that exist with the Navy's paper-based system for handling message traffic and explored some opportunities for improving it. This chapter presents a systems analysis for a new computer-based information system that addresses the problems with the current procedures and provides enhanced capabilities for processing and using messages.

Systems analysis is the first phase in the project development life cycle of new information systems. This phase typically involves surveying the situation, studying the current system, defining user requirements and evaluating alternatives. (Whitten, Bentley, Ho, 1986, p. 8) The problems that exist with paper-based information systems aboard ship and the current state of automating naval messages were addressed in Chapter II. These issues represent the survey and study phases of the analysis. The following sections address user requirements, design principles, application alternatives, and methodology.

A. DEFINING USER REQUIREMENTS

The objective of the proposed system is not simply to duplicate current message handling procedures electronically but to improve them by adding additional capabilities. The definition phase of systems analysis seeks to identify what these capabilities are without specifying the details of how they will be accomplished. The approach to this phase identifies the "knowledge workers" who will use the system, reviews the "business mission" of the

organization, and defines the information system functions that the new system must provide. (Whitten, Bentley, Ho, 1986, p. 191)

1. Knowledge Workers

This information system is being developed to support the users of message traffic aboard ship (hereafter referred to as users). This is a diverse group, typically consisting of all officers, chief petty officers, and selected members of the crew. The needs of the users will vary according to their assigned tasks and responsibilities. The information contained in messages is used for a variety of purposes, including: keeping current with ongoing events, providing guidance in the performance of designated duties, and responding to messages requesting that information be provided to another activity. An automated message handling system must be capable of supporting these user needs and providing desired functions in a manner that enhances the performance and efficiency of the current manual system.

2. Business Mission

An important aspect of developing a new information system is to determine if the system helps to fulfill the business mission of the organization. The mission of the Department of the Navy (DON) is to be prepared to conduct prompt and sustained combat operations at sea in support of United States national interests. The DON Strategic Plan for Managing Information and Related Resources (IRSTRATPLAN), SECNAV INSTRUCTION 5230.10, identifies several information trends related to the DON mission that support the need for an improved shipboard message handling system. These include:

- Information overload of both the commander and the telecommunications facilities is continuing as a result of the implementation of modern

computing power and the demand for more real-time tactical, logistics, and intelligence information. (SECNAVINST 5230.10, 1988, Encl 1 p. 4)

- The efficient utilization of information resources is a tactical necessity to the operational commander when executing an expanding mission with fewer resources. The ability to properly manage information can be the force multiplier to offset resource shortfalls. (SECNAVINST 5230.10, 1988, Encl 1 p. 5)

- The need to provide quality processed information to the commander/decision maker in the most useful format. (SECNAVINST 5230.10, 1988, Encl 1 p. 14)

- An increased demand for information, available and usable within the manager's or decision maker's work space. (SECNAVINST 5230.10, 1988, Encl 1 p. 7)

- A growing demand to transition from hard copy to electronic media for technical information. (SECNAVINST 5230.10, 1988, Encl 1 p. 7)

- Potential to reduce the paperwork burden on both professional and support staff through office automation in an integrated environment. (SECNAVINST 5230.10, 1988, Encl 1 p. 13)

3. Information System Functions

The purpose of this aspect of the analysis is to determine the user's information requirements. The factors brought out by identifying the system's users and examining the role of information in the business mission of the organization facilitated the identification of these requirements. It was determined that the improved system must provide for the distribution, storage, retrieval, and generation of messages. To accomplish this, mechanisms must be provided which allow the users to perform the following actions:

a. Review Newly Received Messages

Messages are received on a continuous basis by the ship's communications center. Users will typically pick up and review the messages distributed to them one or more times each day. The frequency of this review tends to increase during underway operational periods. The proposed

automated system must provide users with a mechanism for scanning a list of messages that have been received since the last review process. This list can then be used as a tool for selecting messages and displaying them on the screen. Users can read messages displayed at local terminals and take appropriate actions on them without requiring that a paper copy be distributed.

b. Organize the Storage of Messages

Messages that have been received and reviewed often have value for future reference. All messages received must be captured and stored by the system. Each receiver of message traffic will have their own context for how the message may be of use to them at a later time. The value of messages will vary based on their content. Some traffic may be rapidly identified as holding no future value, while others may be needed by the user throughout an entire six month deployment. Selected categories of messages may be required which date back years, even to the commissioning of the ship. The system must provide users with a mechanism for organizing and filing these processed messages.

c. Retrieve and Review Previously Received Messages

Users must be provided with access mechanisms for retrieving and reviewing messages that have been previously processed. This need is especially important for examining those documents that are cited as references in other messages. The message of interest may be one that was distributed to the user and filed, or one that was received by the command and not distributed to user for some reason. Various access mechanisms must be provided to ensure that every message received can be accessed.

d. Annotate Messages with Comments and Highlighting

When users read their message traffic they may want to customize some of the documents with comments, instructions or highlighting so that it conveys greater meaning or serves as a reminder during subsequent review. The system must provide mechanisms enabling users to perform these tasks.

e. Route Messages and Annotations

The receiver of message traffic may determine that information contained in messages or personalized annotations is needed by other users on the ship. An example of this might involve a senior informing a subordinate about some required action that must be taken. To facilitate this requirement the system must provide a means for routing message material amongst its users.

f. Keep Track of Action and Response Items

Some of the messages reviewed will require a specific action to be taken or a response to be sent. With the large volumes of messages sent and received by ships, keeping track of these requirements can often become a difficult task. A common solution to this problem is to maintain a running list of all required actions and responses. The common name for this list is a "Tickler" file. Such files are often maintained on personal, departmental, and command levels. The system must provide a means for creating and maintaining such lists.

g. Draft Messages and Route for Approval

In addition to the receiving and reviewing functions, users are often required to initiate messages that are transmitted by the ship to other

commands and activities. The drafting of messages requires that users follow rigid format and content rules. The system will provide tools that will facilitate adherence to these rules, and allow users to take full advantage of information contained in previously processed messages. Draft messages must also be routed to various officers on the ship for approval before they can be released for transmission. The system will provide a mechanism for routing electronic message drafts through the chain of command instead of paper ones.

B. PRINCIPLES AND DESIGN ISSUES

In evaluating alternative solutions and designing an automated system for handling shipboard message traffic, important considerations must be made with regard to the Navy's existing policies, both formal and informal. Changing any system raises certain concerns, but one as critical as an interface between the communications center and the users of message traffic deserves even greater attention. The fundamental issues that will be considered include:

1. Integrity and Security of Messages

The single most important issue that must be considered is maintaining the integrity and security of the messages handled by the system. Naval messages are a formal means of communication. The nature of the information they contain requires that measures be taken to ensure that messages cannot be altered, lost, or destroyed by inadvertent or malicious means. This requires that the system provide built in security measures and redundant storage mechanisms.

2. Ease of Retrieval

Facilities must be provided to ensure that any message received by the system can be quickly and easily retrieved. During the initial review stage users will sit down at remote terminals and call up a list of messages that have arrived since their last review session. The user will then select a message from the list to be retrieved and displayed on the screen. This process should be simple and fast. The time taken to retrieve the message should take no longer than that required to turn the pages in a stack of message traffic. When a user identifies a need for a previously processed message he must first locate or identify the message and then initiate a retrieval. The user may only have a limited amount of time to obtain this message so speed and simplicity must be considered important factors. Ease of retrieval is an essential ingredient for guaranteeing user acceptance of an automated replacement for the current system.

3. Access

Another key issue deals with user access to information. Here Navy policy firmly dictates that only those personnel having the proper security clearance and need for the information can have access to it. Provisions must be made to enforce these constraints, preventing the system from facilitating any unauthorized access to messages. This concern applies to subsequent routings in addition to initial distributions.

4. Flexibility

The flexibility of the system is another important issue. Though numerous standards and regulations exist concerning the handling of messages, each command is likely to have specific individual requirements that

need to be supported. Commands must be able to control distributions and routings as well as the organization of information structures for the filing and retrieval of messages. Since users will establish personal structures for arranging their information, the system must be capable of reorganizing these structures when an individual's needs change or a user transfers and is replaced by someone else.

5. Ease of Use

The knowledge workers for whom this system is proposed represent intelligent end users, but this does not imply that their sophistication can be an excuse for complicated commands and operating procedures. The system must be friendly enough to encourage use, making it easy to review messages, file and locate them for subsequent retrieval, and generate new ones.

C. EVALUATION OF ALTERNATIVE SOLUTIONS

The purpose of this phase of the systems analysis is to determine the best solution that will satisfy the user requirements for the new information system. (Whitten, Bentley, Ho, 1986, p. 191) Three computer-based alternatives were considered for improving the handling of message traffic aboard ship. All three involved use of digital storage media to support the trends of the "paperless" ship initiative. The options included existing relational database methods, traditional electronic mail (E-mail) systems, and a relatively new area of technology called Hypertext.

1. Database

Traditional database methods could be used to order and retrieve messages based on values in their formatted fields. The Navy's strict formatting requirements make this a feasible solution. Messages could be stored and

uniquely identified for retrieval by their Date Time Group (DTG) and originator. Use of the Standard Subject Identification Codes (SSICs) could provide a means for ordering and retrieving information based on preset subject breakdowns. Authorization constraints specifying limitations on the types of actions users can perform could be used to enforce access restrictions. (Kroenke and Dolan, 1988, p. 249) The database approach appears sufficient for organizing storage in an electronic form which would reduce current requirements for paper. However, a traditional database solution fails to fulfill some important user requirements. A database could provide for centralized retrieval, but it would lack the personal context required by the system. The capability to maintain a personal file organization and annotate messages without altering the originals is not easily facilitated in this environment. The "view" feature of relational database management systems (RDBMS) enables the user to customize the presentation of information based on the record oriented data contained in the formatted fields of the message. While this feature provides a certain degree of flexibility to meet the changing needs of individual users, the database approach severely limits the potential for dealing with the material contained in the body of the message. A RDBMS would treat the entire body as a single data item. Such a system would be useful only as a tool for displaying selected messages. Database user interfaces, while improving, often require the user to learn and remember a query language in order to gain access to the information. Current database systems lack the ease of use called for in the design issues. If the user's only concern were retrieval a database might be satisfactory, but such an

approach fails to address many of the user requirements and would severely limit the usefulness of the information stored.

2. Electronic Mail

Electronic mail systems provide a means for sending, receiving, storing, and forwarding messages in digital form. On the surface this seems like the perfect solution to the problem. An E-mail approach would certainly be able to handle the distribution and review requirements. The need for paper would be significantly reduced, but an E-mail system would result in the redundant electronic storage of messages in a similar way that paper is redundantly stored in the current system. This wastes large amounts of electronic storage and creates difficult data management problems. Despite the fact that protection mechanisms can be employed, the presence of multiple electronic copies of documents raises concern over the integrity and security of the message, and the ability of unauthorized personnel to access it. Most E-mail systems lack the file organization capabilities and flexibility specified in the user requirements. Many systems simply provide the user with an unstructured "mailbox" for holding messages. Those E-mail systems that permit "filing" often require the user to remember specific commands for moving and retrieving messages. The failure of these systems to fulfill the "ease of use" requirements often discourages users from organizing their messages. The ability to annotate without altering the original message is also missing. E-mail is a more promising alternative than the traditional database approach, but it also fails to meet significant system requirements.

3. Hypertext

Hypertext systems were the newest and least understood alternative at the outset of this investigation, but it was also the one that offered the greatest potential for revolutionizing the usage of shipboard message traffic. Recent computer hardware and software advances have permitted the development of systems which allow electronic links to connect logically related pieces of information. Such systems allow the user to interact directly with information, giving them increased control over how the information is organized for retrieval and review. This concept of linked documents which can be accessed in a nonlinear fashion is generally categorized as Hypertext. (Chickering and Qualls, 1989, p. 61)

The ability of Hypertext to electronically link information, when applied to the Navy's shipboard message handling procedures, creates opportunities for users to annotate and highlight important portions of messages without altering the original document. The user can immediately reference related documents, in addition to indexing and filing for later retrieval. Indexes and file organizations can be easily changed giving the user a great deal of flexibility. By distributing electronic links only a single copy of the original message needs to be stored. This further supports the issue of maintaining the security of the message. The issue of access control can be addressed by requiring the distribution and routing of links to be approved by the ship's communications center.

While database and E-mail systems offer a more conventional and established solution, the unique capabilities of Hypertext resulted in its choice as the best alternative for designing an improved system for handling

messages. The system, which will be referred to as AMHS—Automated Message Handling System, is introduced as a potential interface between the communications center and the users of naval messages. AMHS could fit into the existing automation efforts presented in Chapter II, by filling the role of the Office Automation System proposed in the NAVMACS/PCMT interface design.

D. METHODOLOGY

Hypertext has been described as a hybrid that cuts across the traditional boundaries of computer science. (Conklin, 1987, p. 33) As an emerging technology there is no generally accepted method for designing and building Hypertext systems. However, many of the principles from existing methodologies can be successfully applied. The approach taken thus far has followed the early phases of the traditional systems development life cycle (SDLC). To continue this approach into the design phase would involve such tasks as designing outputs and inputs, files and databases, terminal dialogue, methods, procedures and programs. The output of such a design is a detailed set of specifications. (Whitten, Bentley, Ho, 1986, p. 377) While appropriate for some systems, the rigidness of this approach often fails to keep the user adequately involved during the development process. The potential impact is that the delivered product may not fulfill user needs.

Prototyping is an alternative approach that is gaining acceptance as a means for refining user requirements and designing systems. Prototyping combines several phases of the SDLC, consolidating the refinement of user requirements with the design and sometimes encompassing portions of final system construction. This approach emphasizes rapidly building a model of

the final system that can then be reviewed with the users to determine if it is accurate and appropriate. The process is iterative, with the model going through several stages of refinement until the users are satisfied that the system interface and functionality meet their requirements. Prototypes can be either paper or working models. Depending on the level of sophistication, a working model might evolve into the final system or simply be discarded after it has served to define the user requirements. (Whitten, Bentley, Ho, 1986, p. 384)

Rapid prototyping was chosen as the development methodology for the Automated Message Handling System. Several off-the-shelf, commercially available products were utilized as prototyping tools. Guide, a Hypertext product for the personal computer, marketed by Owl International was used to demonstrate the application of Hypertext mechanisms to naval messages. Versions of this product, which run on both IBM compatible and Apple Macintosh machines, were utilized to illustrate the independence of the design from hardware configuration. The features of Apple's HyperCard were also examined, though only a partial prototype was developed. A prototype of the system's user interface was developed using NextStep, a user interface and development environment for the NeXT computer.

Prior to commencing the prototyping effort a thorough review of the Hypertext literature was conducted. As a relatively new field of computer science it was very important to gain a complete overview of the subject before designing a system based on its principles. This approach reduced the potential for limiting the system design to only those features available from the prototyping tools. Hypertext deals with some difficult conceptual issues

regarding the structuring and ordering of information. The following chapter discusses the vision and mechanisms of Hypertext. This narrative lays the groundwork for introducing the design of the Automated Message Handling System which is presented in Chapter V.

IV. THE VISION AND MECHANISMS OF HYPERTEXT

A. INTRODUCTION TO HYPERTEXT

The term hypertext was originated by Theodore Nelson in the 1960's to refer to nonlinear text systems which could be used for the creation and review of documents. Nelson's vision was that text stored digitally in the computer could be freed from the traditional boundaries associated with paper and arranged into new types of units or structures. The user would have the flexibility to control his path through the information by making choices and branching to segments that interested him. (Nelson, 1967, p. 195) He described hypertext as

> the combination of natural-language text with the computer's capacities for interactive, branching or dynamic display, when explicitly used as a medium. (Nelson, 1967, p. 195)

Many authors have described this term, but there seems to be little consensus regarding its definition. Hypertext has been labeled as an environment for interconnected writing and literature storage (Fiderio, 1988, p. 237), a style of building systems for information representation and management (Halasz, 1988, p. 836), a model based on the assumption that human idea processing occurs through association (Carlson, 1988, p. 94), and an approach to information management (Smith and Weiss, 1988, p. 816). Hypertext is all of these things. There is no single agreed upon definition for hypertext, yet the majority of authors who have written on the subject seem to have developed a similar mental picture of what it is.

From the standpoint of computer science, hypertext can be viewed as a hybrid. It combines features from database technology, representation schemes, and user interface models to create a unique environment for storing and using information. (Conklin, 1987, p. 33) Conklin in his introduction and survey article focuses on hypertext's machine-supported links. He, along with many others who have described hypertext systems, considers links to be the essential distinguishing feature of hypertext from which all other aspects are based. Electronic linking is the capability that makes it possible to organize text nonlinearly. The term nonlinear refers to the ability to handle material without being constrained by the physical medium. The user determines the order to view information instead of being constrained by a strict sequence created by the author or designer of the system. Another feature very common to hypertext systems is the use of windows. Windows on the screen display information which has been divided up into small segments and stored as nodes in a database. There is a one to one correspondence between these windows and the database nodes. (Conklin, 1987, p. 18) The segments, or units, of information are connected to one another by electronic links. Users traverse the database by selecting and following links from one unit to another. (Akscyn, McCracken, and Yoder, 1988, p. 820)

A wide range of uses are envisioned for hypertext. These include systems for storing and distributing literary and reference information, for providing a collaborative environment on large group projects, and for assisting individuals and small groups involved with authoring and idea processing. Despite the large variation among these projects, the common concept is that infor-

mation should be organized into networks of nodes and links. (Halasz, 1988, p. 840)

Recent interest in hypertext is attributable to technical innovations yielding more powerful workstations, high-resolution graphic displays, increased networking capabilities and decreased cost of large on-line storage. Mechanisms have been developed which permit the user to make direct machine supported references from one text document to another. New interfaces allow users to interact directly with these pieces of information, creating new relationships between them wherever they deem necessary. (Conklin, 1987, p. 17) The release of products for personal computers such as Guide and Hypercard, although lacking some of the features of high priced systems developed for the workstation market, has sparked a greater awareness and interest in hypertext. (Smith and Weiss, 1988, pp. 816-817)

B. THE HISTORY OF HYPERTEXT

Despite all of its recent attention hypertext is not a new idea, but rather one that has developed from visions for improved usage of information and technical innovations in the field of computers.

1. Manual Hypertext Systems

Manual hypertext type systems have been around since long before the conception of modern computer systems. The familiar stack of 3 x 5 index cards and the handy reference book are good examples of manual hypertext systems that are still in use today. These early systems characterize some of the important attributes of hypertext systems. The concept of taking notes on an index card emphasizes the modularization of information. The user limits the contents of the card to a single fact or small grouping of facts. Cards can

be referenced to one another by a number or coding scheme, and they can be easily reorganized to reflect a new emphasis or direction. One of the difficulties with such a manual system is locating a particular piece of information when there are a large number of cards. Reference books, such as the dictionary and encyclopedia can also be considered hypertext documents. The encyclopedia is a good example because as the user reads through a particular section, references are made describing where to locate more information about related issues. This type of referencing is a key feature attributed to hypertext systems. (Conklin, 1987, p. 20)

2. Bush's "Memex"

It is interesting to note that the first automated "hypertext" system was envisioned before the age of computers and decades before the term hypertext would be used for the first time. In 1945 Vannevar Bush, science advisor to President Roosevelt, described a system that foreshadowed the development of modern day information systems. In his article "As We May Think," he discusses the need to improve the methods in which information is recorded, stored, and consulted. Forty-four years ago he described the methods of transmitting and reviewing information as being generations old and inadequate for user needs. Bush felt that the proliferation of information at that time had grown far beyond people's ability to make any real use of it. His foresight into the expansion of printed information caused him to suggest a means for storing records and ensuring that the information could be updated and extended so that it would retain its usefulness. Aware that paper was not a suitable means for maintaining such large volumes, he suggested that microfilm be used to compress information into a smaller storage format.

(Bush, 1945, pp. 101-108) He did not foresee digital storage mediums, such as magnetic and optical disks which make compression even more feasible.

Bush identified the key difficulty in retrieving information as stemming from the artificiality of indexing systems. Under conventional means, when information is stored it is arranged either alphabetically, numerically or according to some other system of organization. To find information with such a system it must be traced through the index until it is located. If the proper index entry cannot be identified the user may never find the desired document. Bush envisioned an improved means of indexing and retrieval based on the functioning of the brain:

> The human mind does not work that way. It operates by association. With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain. The speed of action, the intricacy of trails, the detail of mental pictures, is awe-inspiring beyond all else in nature. (Bush, 1945, pp. 101-108)

He acknowledges that while we cannot possibly hope to duplicate the brain's processes with a machine, there is a great deal that can be learned from it. He felt that man might even be able to make improvements over the brain in the area of permanency of information. His vision was to develop a mechanized system based on selection by association instead of by indexing. (Bush, 1945, pp. 101-108)

Bush describes a mechanized personal library system in his article. He calls this system "Memex," and describes it as a device used to store a user's books, notes, and correspondence in a form so that information could be accessed real time with speed and flexibility. The system would give the user the capability to browse through existing information as well as create new

pieces. He envisioned the "Memex" as a supplement to the user's memory. (Bush, 1945 pp. 101-108)

Bush identified the most essential feature of the system to be the provision for tying items together. This allows any item to be selected and displayed automatically from another item. When a series of items are joined together they form a trail or document that can be reviewed. This adds great flexibility, since a single item can become a part of numerous trails. Other advantages include the fact that trails, once established, do not fade and trails that are of interest to others can be passed between users. (Bush, 1945, pp. 101-108) It is interesting to note that the implementation of Bush's ideas had to wait almost twenty years before the technology advanced to the point where it became feasible.

3. Early Hypertext Pioneers

Vannevar Bush's concepts of associative links and browsing influenced two of the early pioneers in the field of hypertext, Douglas Engelbart and Ted Nelson. Engelbart began work in the early 1960's on a project called On-Line System (NLS) at Stanford University. His goal has been to develop tools for the computer that can be used to "augment native human capacities toward effective action." (Engelbart, Watson, and Norton, 1973, p. 9) NLS, now called Augment, has evolved into an on-line work environment used for the storage of memos, research notes, and documentation. It has been used successfully for several projects at McDonnell Douglas, also serving as an internal communications network. Engelbart is credited with inventing the computer "mouse," and creating the concept of viewing filters. Both of these mechanisms play an important role in successfully building hypertext

systems. The mouse gives systems designers an input device that is quick and easy to use. The user initiates actions by simply pointing and clicking on items, significantly reducing the cognitive overhead associated with remembering commands. The mouse is especially convenient as a tool for activating links, allowing the user to jump to other segments of information in the database. Viewing filters permit users to view a shortened version of documents stored in the database. This gives the user greater control of the presentation. Filters can also be applied to the file or organization structure enabling the database to be quickly reviewed for relevant information. (Fiderio, 1988, p. 238)

Ted Nelson expanded on Bush's concepts, envisioning an on-line hypertext network system containing all the world's literary works. It was Nelson who was responsible for coining the term "hypertext" in 1965 to mean nonsequential writing. His project, Xandau, introduces some important concepts which can be universally applied to hypertext systems. He describes how storage space can be saved and consistency maintained by storing a single copy of the original document. All alterations, annotations, references to related information, and organizational structure of the database are then related to the original through links. Another contribution made by Nelson applies to building hypertext systems. He clearly identifies the need to make a strong separation between the user interface and the database server so that system designs do not limit themselves to a single hardware configuration. (Conklin, 1987, p. 23)

4. The Progress of Hypertext Development

The development of hypertext systems has progressed in stages over the past several decades. The first generation of systems was based on mainframe architecture. Their primary focus was on text nodes, offering little in the way of graphics capability. Systems that are generally grouped in this category include NLS/Augment and ZOG. (Halasz, 1988, p. 840)

The ZOG system is of interest to this study because it demonstrates that the Navy has already had some experience with hypertext systems in a shipboard environment. The ZOG project was developed in 1972 at Carnegie-Mellon University as a menu-based information display system to be used by a large number of simultaneous users. (Conklin, 1987, p. 26) In early 1980 Captain Richard Martin, Commissioning CO of the USS Carl Vinson contacted the team developing ZOG at Carnegie-Mellon University. He was interested in ZOG's potential for managing the tremendous amounts of information found aboard a modern day aircraft carrier. In a joint effort between the group at Carnegie-Mellon and the Navy, a distributed version of ZOG was developed and installed on the USS Carl Vinson. (Akscyn and McCracken, 1985, p. 901)

The sheer size and number of people on an aircraft carrier creates a complex information management situation. The ZOG system targets middle and upper level management as its users. (Yoder, McCracken, and Akscyn, 1985, p. 907) ZOG was designed to provide rapid responses to users' selections for information contained in a large network-structured database. The ZOG system refers to nodes as frames. These frames are structured in such a way as to support a variety of applications. (Akscyn and McCracken, 1985,

p. 901) Over 40 application programs have been created to run on the ZOG/ Vinson system supporting the following ship's functions (Yoder, McCracken, and Akscyn, 1985, p. 908):

- Representing management information about tasks and task assignments (used to produce schedules for management activities).
- Training in weapons and aircraft elevator operation and maintenance (done from an on-line maintenance manual with an interface to a videodisk player).
- Interface to AirPlan, a rule based expert system which assists decision-making for the launch and recovery of ship's aircraft.
- On-line policy manual (Ship's Organization and Regulation Manual).

This early version of hypertext has shown that hypertext can be adapted to a wide range of naval applications, reducing dependence on paper-based systems, and improving information utilization.

The second generation systems began in the early 1980's and are best described as workstation-based, research-oriented tools. Systems that fit into this category include Xerox PARC's NoteCards, Brown University's Intermedia, and KMS, a commercial system developed from the first generation ZOG system. These products are very similar in concept to the first generation systems, but the workstation technology on which they have been implemented allows for a more sophisticated user interface. Another distinguishing feature of these systems is support for graphics and even animation nodes. The second generation also makes heavy use of graphic overviews of the network structure to assist users in navigating through the network and accessing information. (Halasz, 1988, p. 840)

The progress of hypertext over the last several years has been marked by the introduction of systems for personal computers. These products have done much to popularize hypertext, and while more limited in scope and functionality than their workstation-based predecessors they do share many of the same features. The one critical feature not yet incorporated is the ability to generate a graphical overview of the network structure that can be used for browsing through the database. Examples of personal computer products include Guide by OWL International which is available for both IBM compatible machines and Apple's Macintosh, Hyperties developed at the University of Maryland and currently being marketed by Cognetics Corporation, and Apple's Hypercard. (Halasz, 1988, p. 840)

C. HYPERTEXT MECHANISMS AND FEATURES

Although individual products tend to vary somewhat in their characteristics, it is possible to describe the features and mechanisms commonly associated with hypertext in a generic context. This discussion introduces the building blocks of hypertext, nodes and links, and explains how these tools can be used to construct more complex information structures. Various means of accessing information in a hypertext system are also addressed. The terminology and concepts introduced here will be used in describing the logical design for the Automated Message Handling System presented in Chapter V.

1. Nodes

In order to maximize the flexibility and usefulness offered by hypertext, information is organized into small units consisting of a single concept or idea and stored in a database. These units are commonly referred to as nodes. Specific products tend to refer to nodes using a variety of different

labels, such as "card" in Xerox's NoteCards and Apple's Hypercard, and "frames" in KMS. Since small segments can usually be scanned faster than large ones, this organization allows users to rapidly browse through the database. Limiting the scope of the material contained in a node also allows for a more specific and practical organization of the information. Navy messages are generally written to convey information about a particular subject in a concise form. The characteristics of navy messages make them a natural unit of organization for information in a hypertext system.

Segments of information are presented independently, each in its own window. (Chickering and Qualls, 1989, p. 67) While some systems make an effort to limit the size of a node to the amount of information that can be displayed on the screen at the same time, it is becoming more common for programs to allow somewhat longer nodes to be created using scrolling fields. (Fiderio, 1988, p. 238) Hypertext systems typically permit the user to reposition, resize, close, or put these windows aside as small reminder icons. (Conklin, 1987, p. 19) This permits users to focus on certain pieces of information by expanding and placing them in prominent screen locations while other items are displayed in smaller windows or as icons around the periphery. The window display format helps users manage the screen workspace more effectively.

2. Links

The nodes in the hypertext database are interconnected by links. Units of information that are related to each other in some way are electronically linked together, enabling the database to be viewed as a logical network of nodes. (Chickering and Qualls, 1989, p. 67) These nodes may contain link

icons representing pointers to other segments of information in the hypertext database. Activating the link causes the system to jump to the referenced node. The desired information is then presented on the screen in a new window that is created for it. Figure 2 illustrates a group of Navy messages linked to each other to form a network.

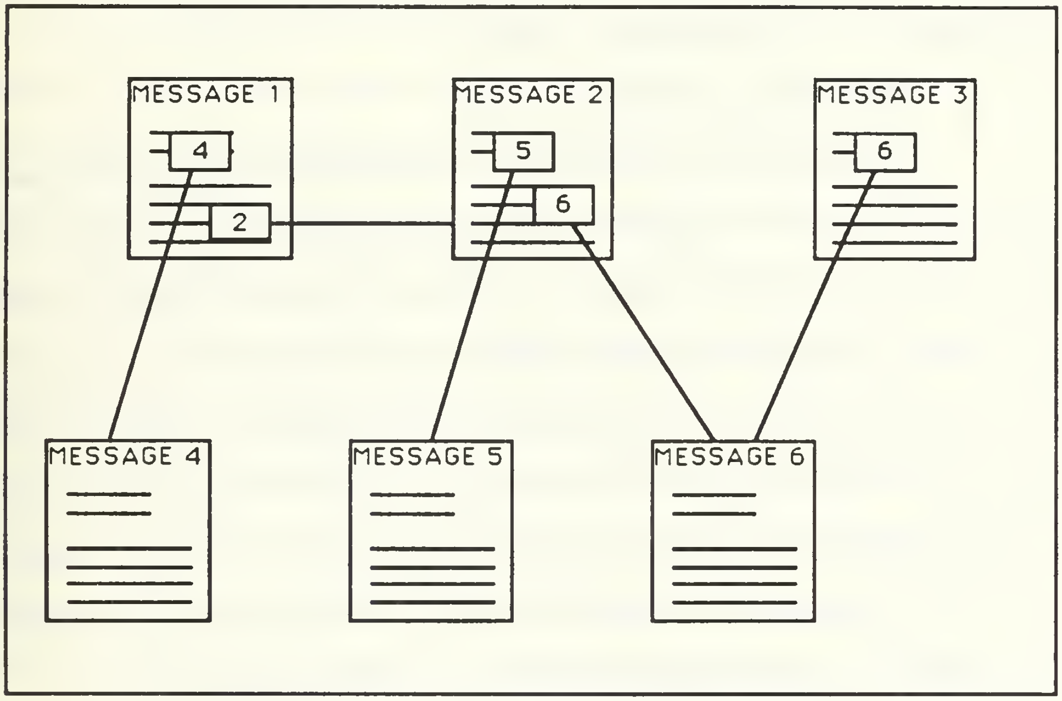

Figure 2. A Network of Navy Messages

Electronic links have been described as "the most distinguishing characteristic of hypertext." (Conklin, 1987, p. 33) An understanding of their properties and capabilities is essential to any discussion of hypertext.

Links are the mode of movement in a hypertext network. Physically this key mechanism is little more than an electronic pointer but conceptually it is more like an electronic footnote, directing the reader to associated text just as a footnote directs readers of printed material to related areas of research. (Fiderio, 1988, p. 239) Links may be either unidirectional or bidirectional. Bidirectional links may be traversed from either end, permitting users to proceed to increasingly greater or lesser levels of detail depending on their needs. (Shneiderman and Kearsley, 1989, p. 3)

a. *Qualities and Uses of Links*

There are several important qualities that links must possess in order to perform their function in a hypertext system. One of the obvious qualities is that the system running the application must be capable of following them. They must also be able to quickly move the user from one node to another. (Fiderio, 1988, p. 239) Activation of a link should be simple and fast. If retrieving and displaying the new document takes too long then the user will become frustrated with the system and stop using it. When a retrieval from secondary storage must be made, some type of visual cue should indicate to the user that the request is being processed. (Conklin, 1987, p. 33)

Hypertext systems can utilize the properties of electronic links to accomplish a variety of functions. These include (Conklin, 1987, p. 33) and (Shneiderman and Kearsley, 1989, p. 3):

- Connecting a reference document to a given document.
- Connecting comments or annotations to documents.
- Providing information about organizational relationships between documents.

- Connecting pieces of information in sequence.
- Connecting brief descriptions to documents that offer more detailed information.
- Displaying an overview: index, table of contents, or browser.
- Transferring to a new topic (subject area).
- Activating another program.

b. Reference Versus Organizational Links

Hypertext documents can be linked together using two broad methods: reference and organization. The reference method does not impose any hierarchy on the structure of the document. Referential links are used to connect points or regions in a document to another node containing information. (Conklin, 1987, pp. 33-34) This is the type of link that would be used to connect comments, annotations, or references to a document. Organizational links are similar to reference links in that they are used to make connections between points in hypertext. However, the difference comes from the structuring of a hierarchy on the information. The concept of organizational links is based on the parent-child relationship or the IsA structure of semantic networks. Figure 3 illustrates this relationship. These types of links will often be employed from a mechanism displaying the organizational structure of the information, as opposed to being included in individual information nodes like the referential links. Examples of such mechanisms include graphical representations and the familiar table of contents. (Conklin, 1987, pp. 33-34) Hierarchical structures allow information to be organized and searched in an orderly manner, with each layer providing increased level of detail. (Shneiderman and Kearsley, 1989, pp. 4-5)

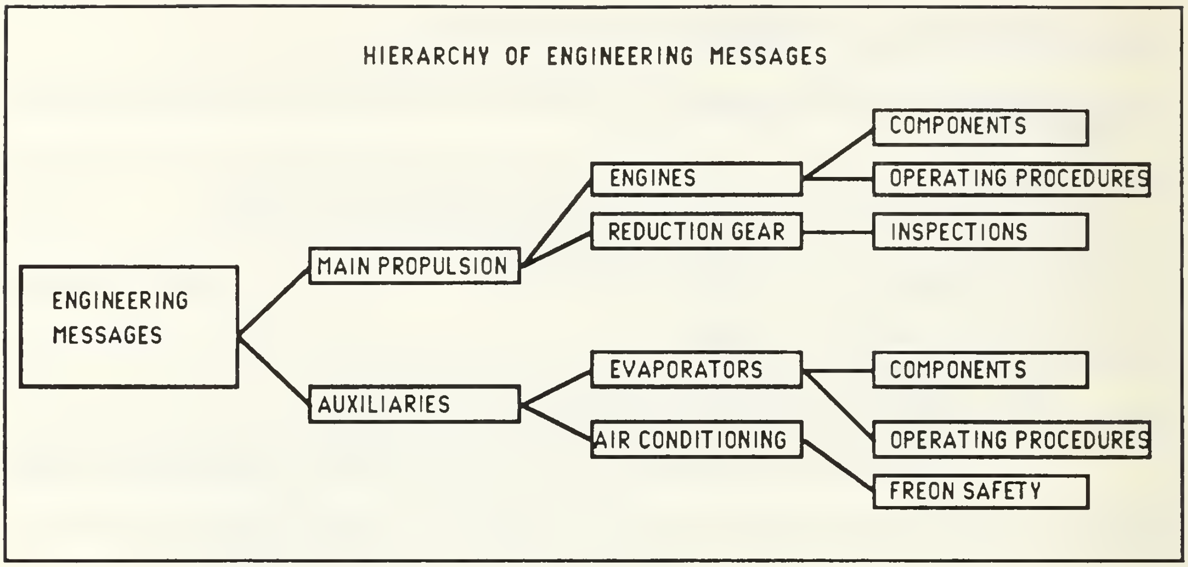

Figure 3. Organizational Links

c. *Typed Links*

Links may be typed or named to describe how they behave and what kind of information is located at the destination. The Guide product from OWL International offers a good example of typed links. Guide has three different types of links: Expansion, Note, and Reference links. Expansion links can be used to replace a selected item. The replacement can be textual information or a graphic. The concept behind expansion in a hypertext system is that clicking on a selected item can reveal increasing levels of detail about a particular subject while remaining in the same document. At the highest levels these details are hidden from the user to present a clear overall picture without confusing the issue with details. As the document is expanded all additional details are presented in context to facilitate user understanding.

Figure 4 illustrates the use of this type of link to expand the level of detail in a table of contents type structure. Selecting Main Engines in the window on the left hand side of the figure will result in an expansion showing the list of subheadings presented on the right hand side.

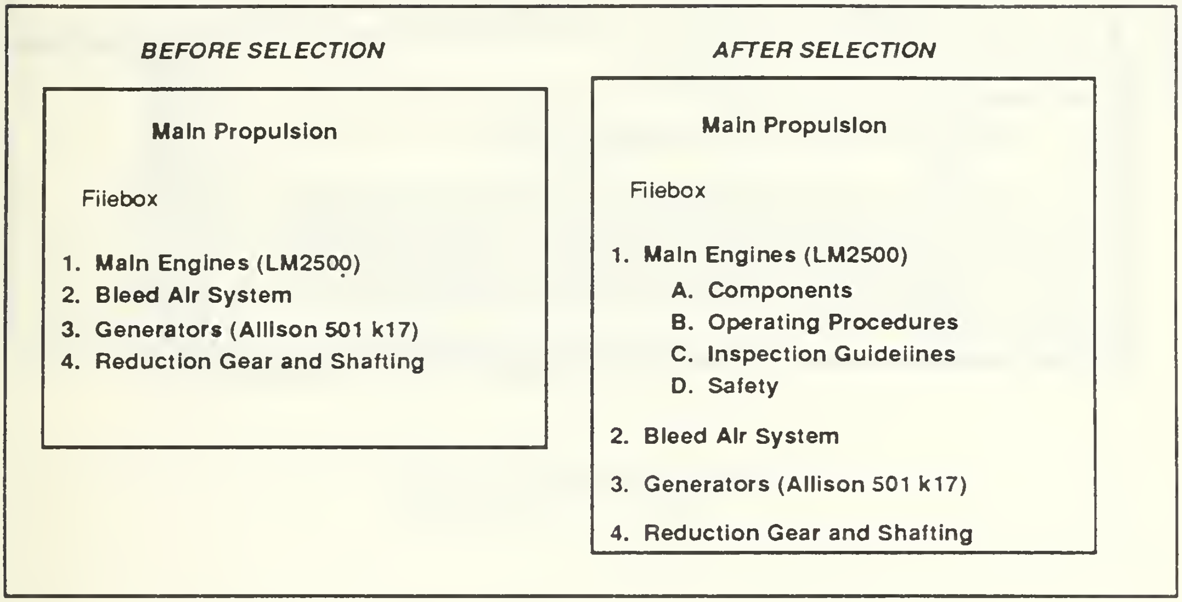

Figure 4. Expansion Links

Note links can be used to present information about a particular selection in a pop up window on the screen. This type of link provides the user with a convenient means to annotate documents with comments or instructions. Figure 5 illustrates a note link implemented using Guide to attach a comment to a naval message.

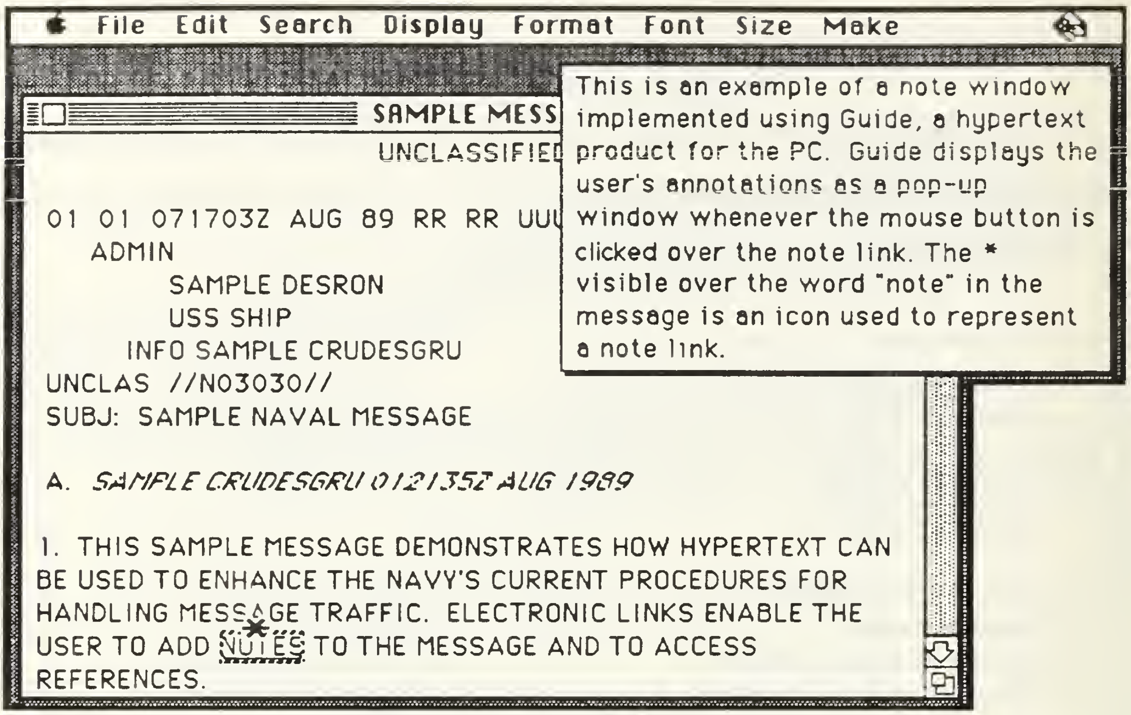

Figure 5. Note Links

Activating a reference link displays the destination document in a new window on the screen. Reference links, as their name implies, are well suited for creating a path between documents and their cross-references. Figure 6 illustrates the use of this type of link to establish a connection between a naval message and its cited reference.

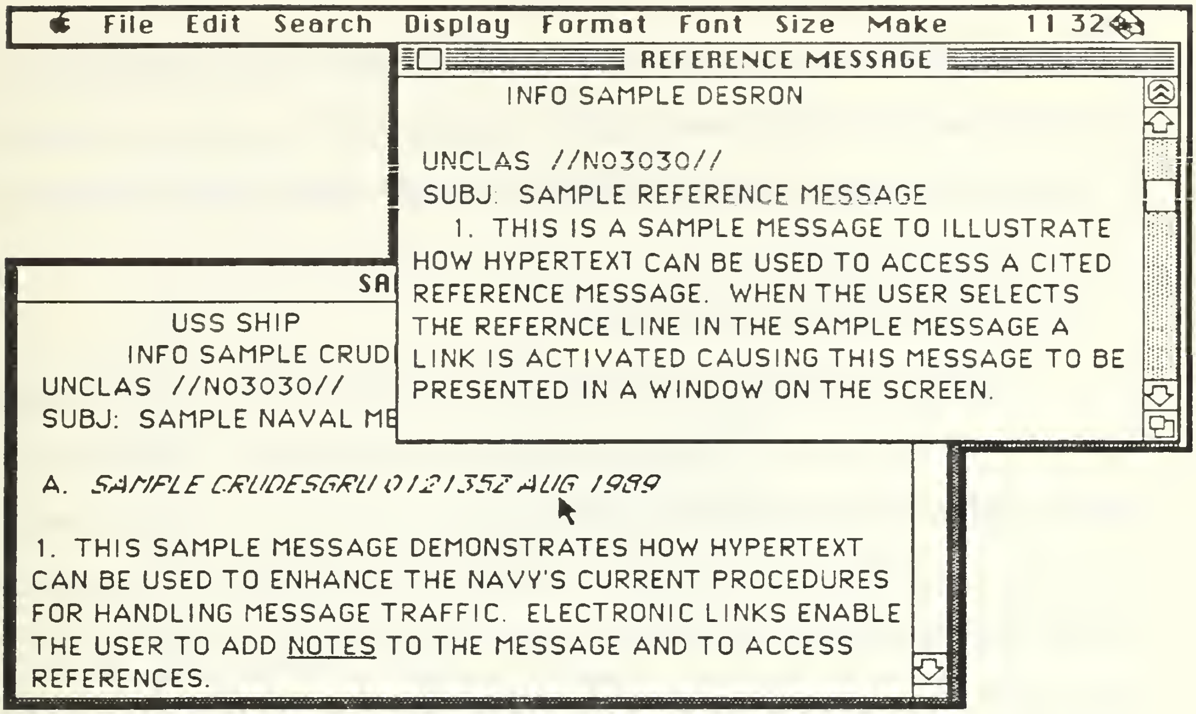

Figure 6. Reference Links

Links can exist as graphical buttons outside the text or may be embedded as words or phrases in the text of the document. Guide uses font styles to distinguish between the different link types. When the cursor is positioned over a link it appears as a link icon corresponding to the type of link represented. The font styles and icons serve as visual cues to assist the user in the selection of actions.

In the majority of hypertext systems links are "anchored" by an icon at a specific location in the source card, but "anchored to the destination card as a whole." Clicking the mouse on the link icon traverses the link, retrieving the destination node and displaying it on the screen. (Halasz, 1988,

pp. 837-838) The fact that nodes are relatively small in size minimizes any confusion that may arise concerning what segment of the destination node is of interest to the user. The referenced node can be quickly scanned to locate the related information.

3. Composition Mechanisms

Nodes and links are the fundamental building blocks of hypertext. These mechanisms enable users to store information in a database and connect logically related pieces together. Some systems allow users to extend this idea by developing their own information structures for organizing information. These systems permit users to modify and add information or restructure its organization by creating, editing and linking nodes. These capabilities represent significant advances for information management, overcoming many of the restrictions that exist with traditional linear documents. (Chickering and Qualls, 1989, p. 67)

Links can be used to connect multiple nodes forming group or cluster links. Uses for such a mechanism include connecting multiple annotations to a document, and creating specialized organizational structures (Conklin, 1987, p. 35) The Xerox NoteCards product has defined two very useful mechanisms for dealing with groups of nodes and links: "head cards" and "fileboxes."

a. "Head Cards"

The "head card" serves an important conceptual function by allowing groups or clusters of nodes to be referred to as a single unit. This mechanism is commonly used in NoteCards to implement higher levels of organization using existing mechanisms. Figure 7 illustrates how the head

card concept could be employed by a user desiring to personalize a message with some notes and comments. Application of this mechanism to the Automated Message Handling System will be demonstrated in Chapter V.

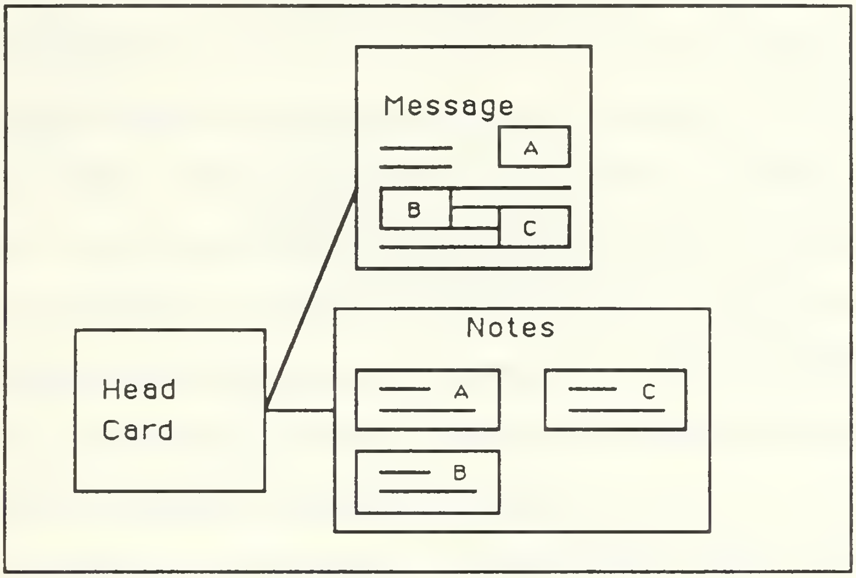

Figure 7. The “Head Card” Composition Concept

Unfortunately some problems exist with the head card concept. Current systems lack an adequate means for displaying and treating the cluster as a single unit. They can either display the head card, which does not show any of the links into or out of the component cards, or show all of the cards in the cluster in a normal manner, which fails to emphasize the grouping. (Halasz, 1988, pp. 843-844) Despite this representation problem the head card composition concept remains a useful tool for designing and building hypertext systems.

b. "Fileboxes"

Another mechanism that can be built from the fundamental node and link constructs is the "filebox." This mechanism is based on the familiar mental model of a file cabinet. Just like the traditional office tool, the hypertext filebox provides a means for organizing information so that the user may easily access it at a later time. One of the more common means of using the filebox arrangement is to organize information hierarchically. (Halasz, 1988, pp. 841-842) The advantage of using such a construct in a hypertext system is that the file organization is accomplished through use of links. This means that a document can be accessed from a variety of "files" or identifiers while only requiring that a single physical copy be maintained in the database. This feature greatly improves the chances of locating desired information when needed without requiring the redundant storage that would be required in a traditional system. Such redundancies could require significant storage even if documents were stored electronically. The elements of the filebox may be represented as a graph, tree or simple list with each item serving as a link to the information. (Halasz, 1988, pp. 841-842) Figure 8 shows a graphical representation of a filebox for the engineering department of a ship. At the lowest levels nodes would represent the head card for a particular message.

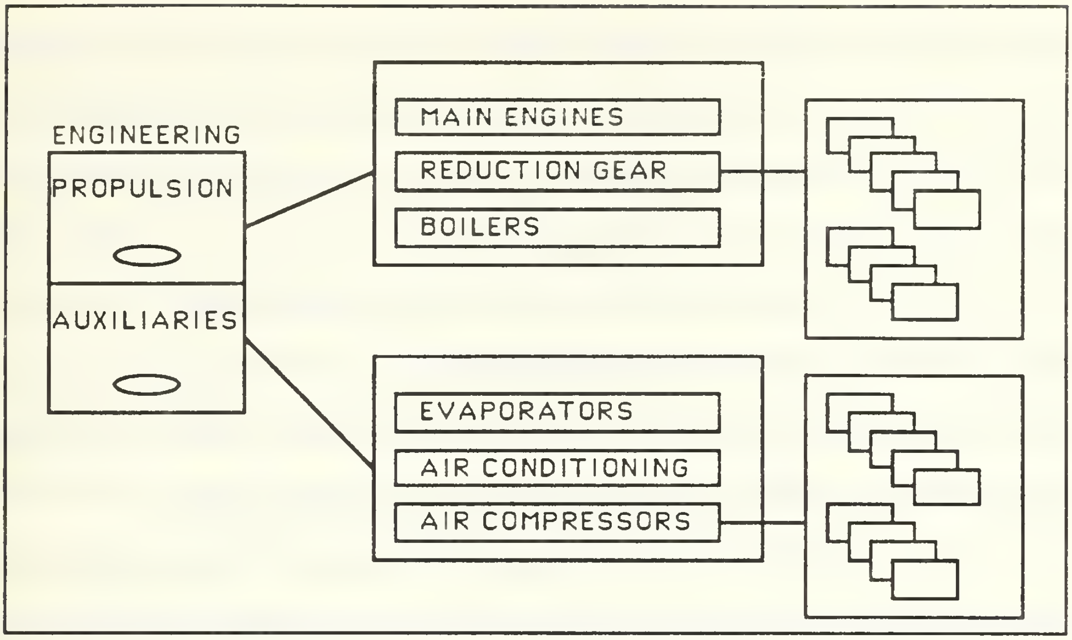

Figure 8. "Filebox"

Xerox PARC's NoteCards makes heavy use of the filebox construct. NoteCards requires that every notecard in the system, including fileboxes, be indexed or labeled in at least one filebox. This ensures that the user will always have some means to locate and retrieve information stored in the database. There is however one major flaw with the current implementation of fileboxes. This mechanism fails to take into consideration the difference between reference and inclusion relations. Fileboxes are typically implemented using the well established reference link. In the example shown in Figure 8 filing a Reduction Gear message would involve establishing a reference link from the message to a head card grouping of messages dealing with that subject. That head card would then be connected by another reference

link to the topic label "Reduction Gear." The user is given the impression of "filing in a filebox" connoting an inclusion relationship, but instead of being "included" messages are actually stored and accessed as references. The differences between user perception and system implementation is a potential source of problems if the user becomes confused about how to use the filebox. (Halasz, 1988, pp. 843-844). Such difficulties can be minimized by designing the system interface in such a way that the user does not have to worry about the differences between reference and inclusion relationships.

The problem of composition has been addressed by Frank Halasz, one of the developers of NoteCards, as a critical issue for the next generation of hypertext systems. He foresees the solution to be the addition of composition as a basic construct in the hypertext model. This would involve an inclusion relation separate and distinct from the current reference link. Such a mechanism would solve the current problems that exist with implementing the head card and filebox concepts using reference links. (Halasz, 1988, p. 844)

4. Information Access

The entire purpose of the mechanisms introduced up to this point is to provide an improved and more natural way for locating, retrieving, and using information. Hypertext allows the information stored as nodes in the database to be accessed in a variety of ways. As a user reviews a document he may decide to activate links and examine references. By following such links the user can wind through the database until a sufficient level of detail is reached. A graphical representation of the database may be used as an aide to navigating the network. Such representations are referred to as browsers.

Another method might entail the use of an index, while a somewhat more traditional approach to locating information may involve performing a database search/query for a specific keyword, phrase, or value. (Conklin, 1987, p. 19)

a. Navigation

Hypertext systems are designed to allow users to skim through, or rapidly pursue, related pieces of information. (Fiderio, 1988, p. 239) This method of browsing and exploring a database is based on association and is significantly different from the traditional systems which access rigidly formatted data records based on the contents of specified fields, keywords, or other identifiers. (Shneiderman and Kearsley, 1989, p. 10) Navigation is a characteristic feature of hypertext, but it can also cause problems in large databases where it becomes easy for users to forget how or why they arrived at their present location. Hypertext's freedom to explore may result in a distraction from the intended goal of answering a specific question or locating a specific document. (Shneiderman and Kearsley, 1989, p. 10) A "graphical browser" node containing a structural diagram of a network of nodes can be used to reduce this problem. (Fiderio, 1988, p. 239) The layout of the network in a browser provides contextual and spatial cues which help to amplify the user's mental model of database. This results in a better understanding of how nodes are related, improving the user's ability to quickly locate desired information. (Conklin, 1987, p. 19) This mechanism can be used for orientation purposes or to help users decide on their next action. (Fiderio, 1988, p. 240) The diagrams presented in the browser are generated for the user by the system. The nodes shown in the browser are actually icons

for traversing links between the browser and the reference document. (Halasz, 1988, pp. 837-838) This mechanism allows the user to immediately access information by clicking on an item of interest without having to issue a separate command. Figure 9 provides a good example of how most browsers are structured. This mechanism is built using the organizational type links that were discussed previously to illustrate the ordering of information in a hierarchy.

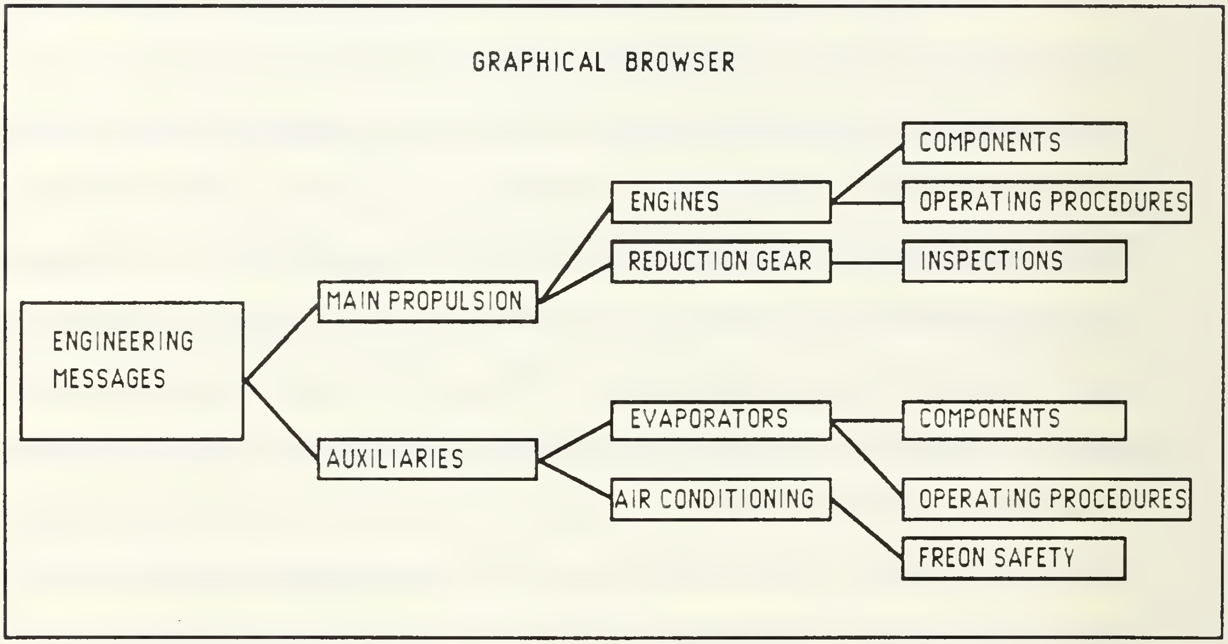

Figure 9. Graphical Browser

Another interesting means of navigating the hypertext network involves the following of predefined paths through nodes in the database. Conklin, in his introduction and survey article, discusses the concept of paths originally developed by Randall Trigg in his PhD dissertation on hypertext. Paths constitute an ordered trail that can be used to browse nodes. They relieve users from having to make decisions at each link, and in essence provide the user with a preset way through the network. Users can also be provided with the capability to browse the database and save the trail followed as a path that can be used again later, or passed to a colleague. (Conklin, 1987, p. 24) This can be a very useful tool in reducing the time and effort required to find information.

b. *Indexing*

While navigation is the primary means of access in a hypertext system, indexing also provides important capabilities. Indexing can be thought of as another means of ordering information so that the user can locate and retrieve items of interest. Nodes in the database may be indexed alphabetically, numerically, or organized hierarchically. Examples of a hierarchy include table of contents or outlines which represent an organizational structure of the database. The nonlinear nature of hypertext provides the potential for a variety of indexes, each describing an alternate organization for the information. (Shneiderman and Kearsley, 1989, pp. 11-12) An item could be listed in any number of indexes while still only requiring that a single copy exist in the database.

Indexes can be built manually by the author or user of a system as well as automatically by a text parsing program. Indexes can be based

on the use of either a controlled or uncontrolled vocabulary. A controlled vocabulary implies that each document is classified by one or more entries from a specified list of terms. The nature of the application or the characteristics of the organization may determine the vocabulary to be employed, or it may be up to the user to create an individual index. The difficulty with such a system is that a suitable vocabulary must be created so that each node is classified by at least one term. Additionally the index must have a relatively uniform distribution of classification terms among all the nodes to ensure its usefulness as an access mechanism. (Frisse, 1988, p. 250)

Another powerful document-indexing technique is classification with an uncontrolled vocabulary. This method can be used when a controlled list of index terms is not available. With an uncontrolled vocabulary, inverted indexes are created by eliminating "stop" words (the, are, a) and removing suffixes (-s, -ing, -ed). The remaining word roots are retained in an index file, which in general will be about one half the size of the original text file. Many who favor this approach argue that it is an effective way to retrieve information. This form of indexing is currently being used by a variety of applications for the retrieval of information from optical storage media. However, in many cases the amount of storage needed to maintain the indexes and the problems caused by misspellings and synonyms outweigh the benefits of this method. (Frisse, 1988, p. 250) While an uncontrolled vocabulary index guarantees comprehensive access it may result in overwhelming responses which are time consuming to review, further reducing its advantages. (Shneiderman and Kearsley, 1989, pp. 11-12)

The nature of the information stored in the database will determine its ability to be indexed hierarchically. If the database consists of numerous unrelated nodes then the hypertext system is essentially just a container for grouping the documents. If on the other hand nodes share a highly structured relationship with each other, retrieval techniques, such as a hierarchical index, can be exploited to gain true benefits from the hypertext interface. (Frisse, 1988, p. 250)

A multi-level hierarchical organization is a common mechanism for structuring a hypertext database. In such a hierarchy, the top levels function as an index to the database. As the structure descends further down into the database, levels representing individual documents are revealed. The user can augment the hierarchy by creating links to cross-references and annotations. (Akscyn, McCracken, and Yoder, 1988, p. 822) Such a mechanism enables the user to locate information by scanning a category structure that becomes increasingly more specific at the lower levels. The user can visually scan the hierarchical index and then move directly to areas of the information network that are likely to contain the desired information. (Halasz, 1988, pp. 841-842)

c. Search/Query

Hypertext has become synonymous with navigational access. The ability to browse networks by following links is a characteristic feature of hypertext. However, the experience of hypertext developers with several existing systems, such as NoteCards, suggests that navigation is not sufficient by itself as an access mechanism. (Halasz, 1988, p. 841) Browsing and indexing are both based on the concepts of association, but they will only

work for previously defined links. A more traditional keyword search mechanism is often needed in addition to these capabilities. (Shneiderman and Kearsley, 1989, p. 12)

Halasz identifies two classes of search/query mechanisms that are needed in a hypertext system: content search and structure search. A content search considers all nodes and links in a network as separate entities; each is individually examined for a match to the given query. This type of search ignores the structure of the hypertext network. The structure search on the other hand examines the organizational structure for subnetworks that match a given pattern. (Halasz, 1988, p. 842) This would be a useful technique in limiting the scope of the search and increasing the probability of retrieving the desired information.

In addition to their use for locating information, queries can also be used as a filtering mechanism. A user's description of interest items would be used by the interface to display aspects of the network that matched the query. Irrelevant information would not be displayed. (Halasz, 1988, p. 843)

d. Limitations of Access Methods

An important aspect of understanding any system is the ability to recognize its limitations. There are situations where each of these means of information retrieval in a hypertext system is inadequate. Navigating or browsing through the database becomes a long and arduous process if there are many nodes to examine. Use of a table of contents, browser or some other form of indexing and presentation mechanisms fails when a node can be filed under any one of several categories, requiring a search of several categories to

find desired information. Pattern matching or search/query fails if the desired node uses a synonym or if the search identifies a large number of unwanted cards. (Frisse, 1988, p. 249) No single access mechanism is sufficient by itself, but by providing three different mechanisms hypertext offers users a better opportunity for efficiently locating needed information.

V. AUTOMATED MESSAGE HANDLING SYSTEM DESIGN

The vision and mechanisms of hypertext illustrated in the previous chapter provide the building blocks for designing the Automated Message Handling System (AMHS). The objective of this design is to show how hypertext can be used to fulfill the user requirements and satisfy the design principles that were developed during the systems analysis phase. This design seeks to contribute to ongoing efforts to improve the Navy's communications systems.

The discussion of the "paperless" ship introduced some of the Navy's current automation efforts. The Navy is aware that current systems are labor intensive and error prone. It is also aware that information technology offers a wide range of potential solutions for improving the efficiency and effectiveness of message handling procedures aboard ship. The Navy is presently investigating a personal computer interface to the Naval Modular Automated Communications System (NAVMACS) which would improve information exchange between the communications center and the end user. This system is called the Personal Computer Message Terminal (PCMT). While addressing some of the requirements for improved message handling, PCMT is primarily envisioned as a means for transferring messages between the communications center and the user community through a standard diskette format or via a network. Additional message handling capabilities are to be addressed by Office Automation Systems (OAS). An OAS standard or design has not yet been selected. The design for the AMHS presented in this chapter

can be adapted to fit current Navy efforts by filling the role of the OAS proposed in the NAVMACS/PCMT interface design, or serving as a direct interface between NAVMACS and the end users of message traffic.

The data flow diagram presented in Figure 10 provides a foundation for describing the features of the AMHS. This model was developed from an analysis of the current shipboard procedures and the information requirements of the users for an improved message handling system.

The model depicts the information tasks and flows of data that are involved with processing messages from their initial receipt to use. This is a high level presentation designed to give a global overview of the entire system. Although it is common to model systems independently of the mechanisms that will be used to implement them, this diagram takes into account the electronic linking capabilities of hypertext to emphasize the point that only a single physical copy of the message will be required by the system. The primary functions that will be discussed include message receipt, distribution, review, filing and retrieval, tracking action items and message generation and routing.

A. MESSAGE RECEIPT

The AMHS will be used to electronically capture and store transmitted messages as they are received by the ship. The receipt of the message is acknowledged by entering its identification data into a transaction log. The message is then stored as a text file on a high-density digital storage device. The mostly likely candidate for such a storage medium is an optical disk. A

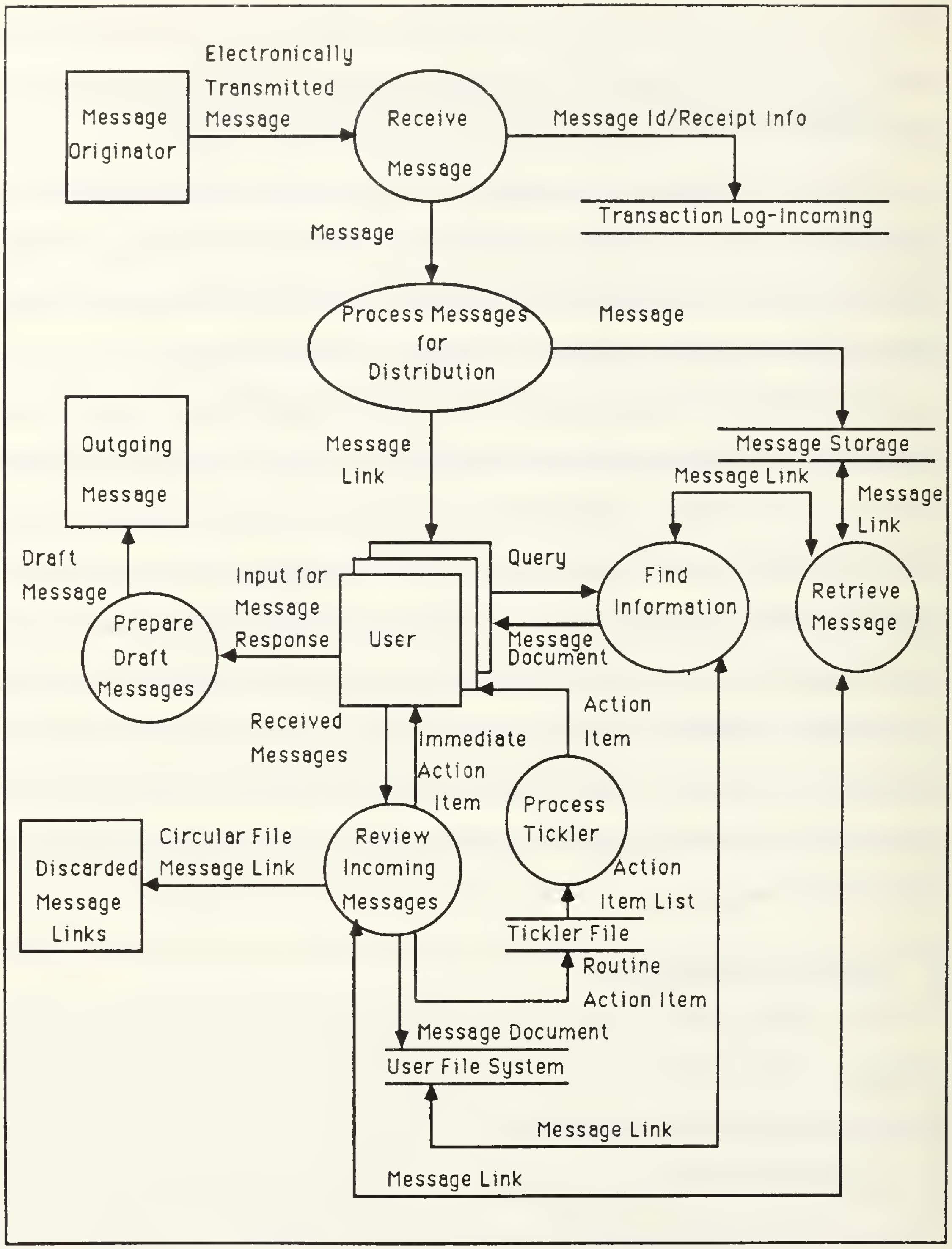

Figure 10. A Model for the Management and Use of Naval Messages

WORM drive would offer capabilities for large storage volumes and also provide physical protection against tampering with the message. Conceptually the messages will be represented as nodes in the hypertext database. Figure 11 illustrates the receipt process and shows how AMHS could serve as an extension of the PCMT system, or as a direct link to NAVMACS.

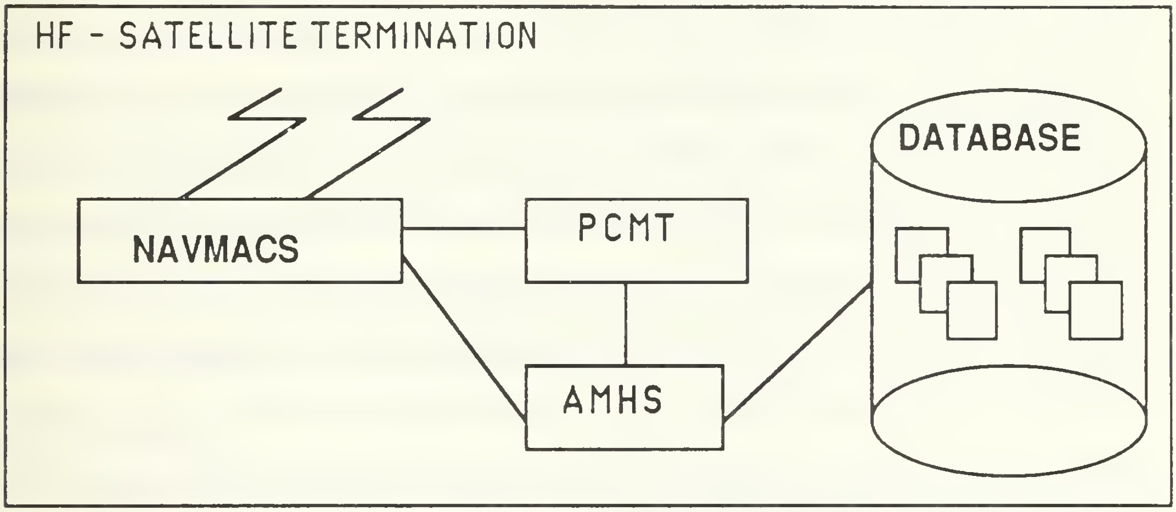

Figure 11. Message Receipt

In addition to capturing and storing messages, the receipt process will also examine messages and automatically create links to formally cited references. The format of naval messages allows for the easy identification of specified references on incoming messages. A text parsing program can be used to create an electronic reference link from the line citing the DTG of the reference in the incoming message to the referenced message held in the database. If the reference cannot be located, a note stating this fact will be attached as the destination of the reference link and sent as notification to

the communications center personnel. The communications center can then take the necessary action to receive a copy of the reference message.

B. MESSAGE DISTRIBUTION

A dissemination system is needed to ensure that incoming messages are properly directed to those personnel or offices requiring this information to perform their jobs. Much of this activity is currently handled by human personnel using local operating procedures to determine who will receive incoming messages. Those ships having NAVMACS V1, V2, or V3 configurations will append an operator specified Local Routing List (LRL) to the bottom of the first page of each message received. The assigned operator is responsible for checking the contents of each incoming message against the distribution lists contained in their operating procedures. The operator annotates the LRL to indicate who will receive a copy of the particular message. The NAVMACS V5/V5A reduces some of the manual effort by assigning actual office code distribution and copy counts based on the system's data base. Each message is then duplicated for distribution and slotted in boxes for pickup by the users. (NAVTASC, 1989) High precedence and secret traffic receive special treatment and are disseminated more rapidly.

These dissemination procedures, combined with the large volume of incoming traffic and the need for the user to keep informed about a wide variety of activities, typically result in a large number of messages being directed to users each day. It is critical that users be able to examine this "daily traffic" and respond to it. Many of the items delivered will be inconsequential and can be processed immediately. Other items, however, may require the user to carry out specific actions, answer certain questions, or submit a

report. Some messages issue procedural guidance that may remain in effect until a revision is made to formal operating instructions, publications or procedures.

AMHS will accomplish the dissemination of messages to users by matching user interest profiles and security classifications against the text of incoming messages. Data available from the NAVMACS system can be used to support this process. The system will be capable of distributing a large portion of these messages automatically, based on the profiles stored on distribution lists. Standard recurring messages will always be delivered to the same individuals or offices. For example, Propulsion Plant Class Advisory messages would always be delivered to the engineering department. It is not necessary for human operators to become involved with messages that can be handled in this manner.

Many of the remaining messages can have assignments suggested by the computer and validated by a human operator responsible for monitoring the system. These suggestions can be made by comparing the text of the message against a list of SSICs, text words or phrases, and originators combined by boolean OR, AND, and NOT operators. After a tentative assignment list has been generated by the computer it is checked by the human operator who then has the opportunity to approve, add to, or modify the distribution.

Once a requirement for distribution has been determined the AMHS must "deliver" the message to the user. This delivery consists of providing the user with an electronic "message link." It is important to reemphasize that one of the distinguishing features of using hypertext for this system is that the actual message is stored only once. Unlike an electronic mail system that

distributes an "electronic copy" to each user's box, the hypertext system distributes links. These message links serve as pointers to the message files that are stored in the central database. Receipt of a message link is equivalent to receiving a virtual copy of the message. Users will not be able to distinguish the difference between this system and electronic mail, but the subtlety of its implementation using links is critical to supporting the functional requirements and design principles that were established in Chapter III. The illusion of having a personal copy of the message allows users to think of the system in familiar terms. They will be able to access, customize, and organize messages just as if personal paper or electronic copies had been distributed. The fact that the system is implemented using links allows these actions to be accomplished and also supports the design principles of maintaining message integrity, controlling access, ensuring ease of retrieval, and providing flexibility. These issues would be far more difficult to handle in an environment where multiple copies existed. Message links are sent to individual user "In-Boxes" which serve as a mechanism for grouping links to newly received messages. The In-Box functions as the user's means for accessing and reviewing daily message traffic.

C. MESSAGE REVIEW

Terminals will be located throughout the ship and networked to a central server in the ship's communications center (remote terminals will be capable of serving as alternate server sites). Authorized users may access the system from any terminal by entering their appropriate password. After log-on, users may decide to review their message traffic by selecting the "Message In-Box" and scanning the list of message Date Time Groups (DTGs) and

subject lines that have accumulated since the last time they accessed the system. Figure 12 illustrates the format for this mechanism. The Message In-Box is presented as a single window on the screen. This window contains two views in addition to a series of command buttons that can be activated to perform additional functions. The upper view contains the list of messages to be reviewed, while the lower portion includes an area for displaying one of the messages selected from the Message In-Box list. A button located between the views will allow the size of the views to be adjusted. During initial presentation of the In-Box list the upper view will be expanded, dedicating a large portion of the window to the list of messages to be reviewed. When the user selects a particular message from the In-Box list it will be presented in the lower view. This view can then be enlarged to focus the user's attention on the specific message selected. The AMHS offers the user additional capabilities over simply presenting the message on the screen for review, including accessing cited references, adding notes and comments, and inserting highlights. Other features such as electronic filing, tracking action items and generating new messages are also available from this window but will be described in subsequent sections since they can also be invoked as independent functions.

1. Cross-Referencing

It is very common for naval messages to reference previously received messages, instructions, or documents. During the review process it is often helpful for users to have easy access to these cited references. The current manual system lacks a consistent means for accomplishing this.

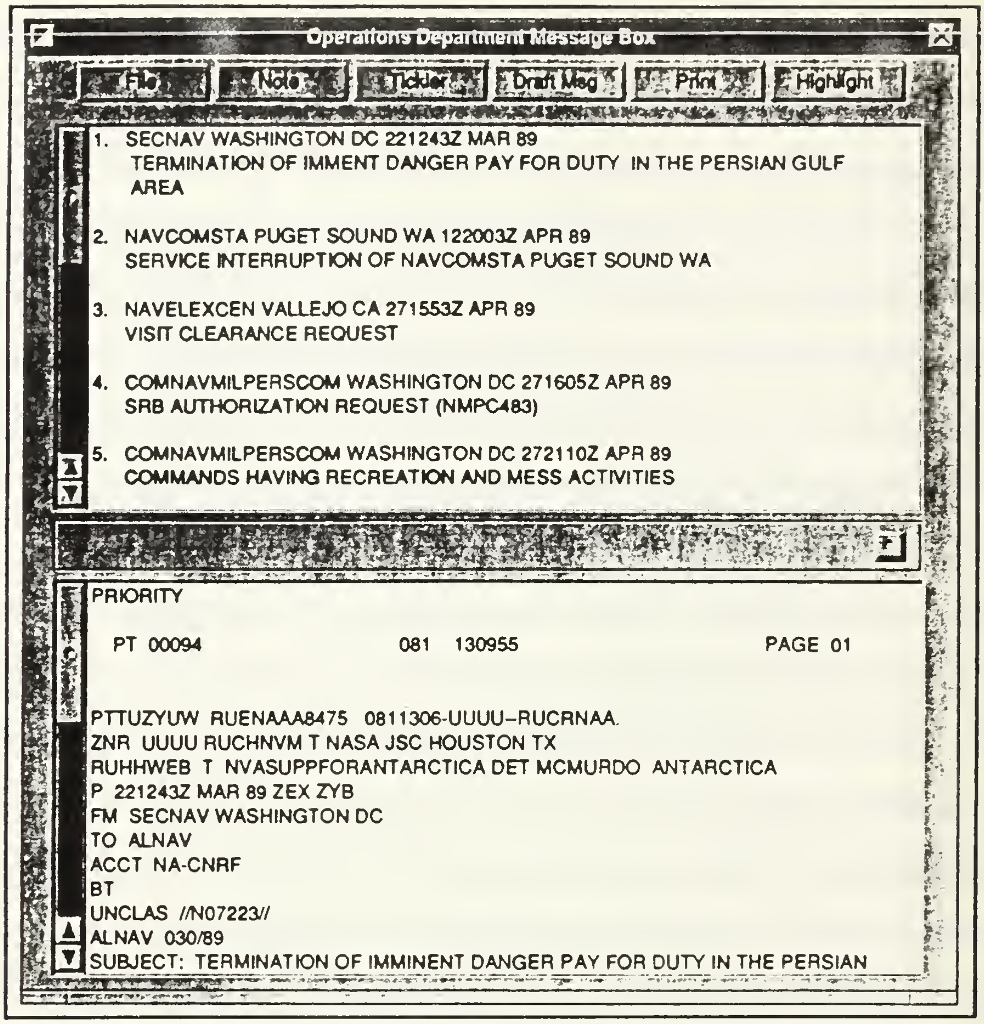

Figure 12. Message In-Box

Under the present system the user's ability to locate a reference depends on a variety of factors; these include: did the user receive a copy of the reference; if a copy was received, was it retained; and if so, under what category was it filed. The current paper-based system fails to provide a rapid method for accessing references, and offers little assurance that they will be located at all.

AMHS is able to greatly improve the process by supplying the user with electronic links to cited references. These links are automatically generated by the system during the message receipt process. During the review phase, all the listed references of a message will appear as link icons. If the user has the appropriate access, activating the link will generate a new window on the screen containing the reference. This capability allows the user to see both a message and its references on the screen at the same time. If the user has not been granted access to a reference, permission to receive it must be requested from the communications center.

2. Annotation

Chapter II addressed some of the advantages and disadvantages of paper-based information systems. One of the advantages discussed was the freedom of the reader to make comments in the margins, highlight portions of the text, underline sections, crease pages, attach post-it notes, or in some other meaningful way customize the paper document. Users often feel comfortable with their own customized edition, but become confused and disoriented when trying to locate information in a document that has been marked by someone else. (Bernstein, 1988, p. 41)

The ability to annotate messages is an important requirement of the AMHS. Hypertext provides powerful capabilities for fulfilling this specification. While reviewing a message a user can call up an electronic notepad in a separate window on the screen. Comments or instructions can be entered into a scrolling text field on the note, which can then be attached to any portion of text in the message that is selected. This anchor for the note may be a single word or phrase that triggers the user's attention to look for

amplifying information. These notes may serve as keys or reminders to the user who created them or they may serve to answer questions or give instructions to other users. (Shneiderman and Kearsley, 1989, p. 41) Annotations will not appear until the user selects them. Thus if the user wants to see the plain text of a message as it was originally received, this view can easily be presented. If the user wants to see notes they can be displayed by the simply clicking the mouse over the appropriate link.

3. Highlighting

The concept of electronically highlighting a document is exactly the same as the manual procedure that takes place when a highlighter or marker is used to set off portions of printed text having greater relevance than others. The objective of highlighting is to save the user time when reviewing messages at a later date. Highlighting immediately calls the users attention to marked portions of the text. Highlighting will be accomplished during the review process by selecting contiguous portions of text that are of special significance to the user. After the text has been selected the user activates a button at the top of the window designating the selected area for highlighting. It is a simple problem for the system to obtain the starting and ending position for selected strings and build these locations into a file.

When the message is called up at a later time the user will be notified that the message being viewed has been highlighted. This can be accomplished by enabling a button labeled "Show Highlights." When a button is enabled it will appear dark to the user, if disabled it will appear shaded. The user then has the option to view the message with the highlighting applied.

Selecting the "Show Highlights" button activates a program to reverse the video for the designated positions in the message being viewed.

D. THE MESSAGE DOCUMENT CONCEPT

Thus far messages have been viewed as nodes in a central database that can be accessed by users through electronic links. Now that the user's capabilities to reference related messages and personalize messages by adding annotations and highlights have been discussed it is possible to introduce a slightly more sophisticated image of the system. In order to provide for these advanced features without requiring the system to maintain redundant copies of the message, it is necessary to employ the mechanisms of composition introduced in the previous chapter.

In Chapter IV the concept of using a "head card" for grouping collections of related nodes and treating them as a single entity was discussed. This concept can be adapted to the AMHS to help explain how users are able to customize their information without altering the original message. AMHS will refer to the mechanism used to achieve this as a "Message Document." The message document concept implies that cross-references, annotations, and highlighting are implicitly tied to the message. In order to ensure the integrity of received messages in an electronic system, annotations and highlights will be stored as separate nodes in the database and linked at a personal level to the user's message document. The original message will remain unaltered. Figure 13 illustrates the message document concept.

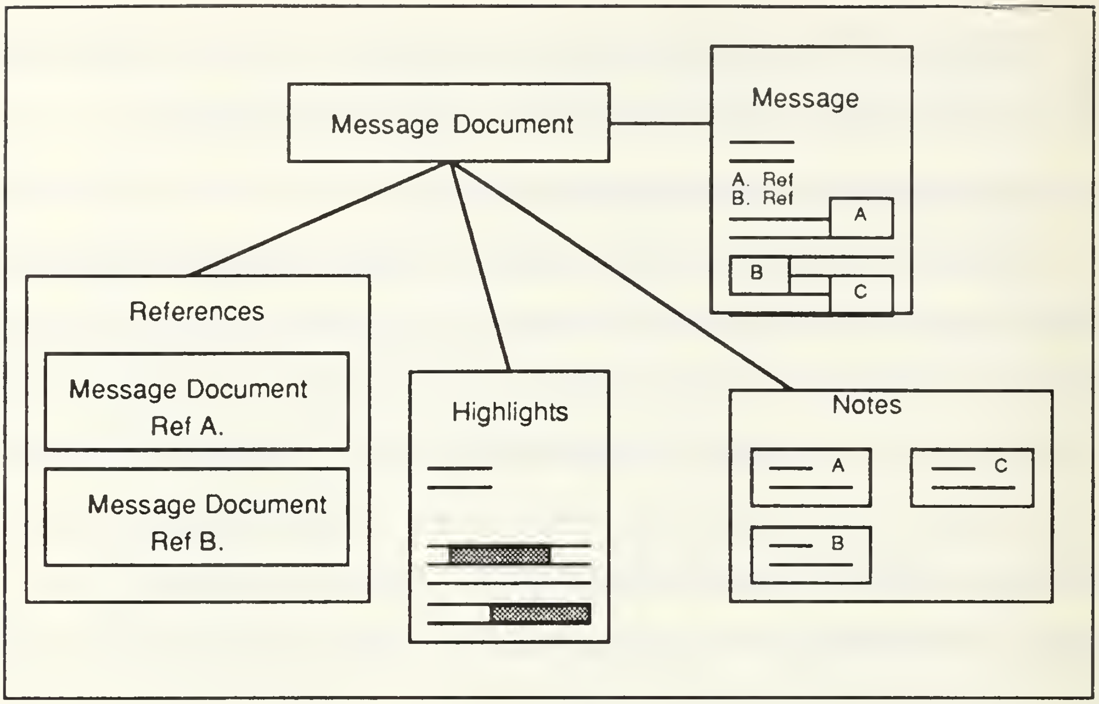

Figure 13. The Message Document

The message document concept helps explain the issue of providing a personal context through which users can access and use the hypertext network. Each user's context consists of a base layer that is the public hypertext network. In the Automated Message Handling System the public network will contain all of the messages processed by the command. Individual users will only have access to a portion of these messages. Users may access any message that they have received a link to from the communications center. If they have not received a link to a particular item that interests them, they must make a request to the communications center before being able to access it. The purpose of this restriction is to support the principle of access that was developed during the systems analysis. Stacked on top of this base

layer are personal layers. These layers are maintained by the user to provide a more personalized view of the information. The first personal layer consists of the message documents. This enables each user who receives a link to a message to create his own context for using the information it contains. Through the message document users may access a message's cited references (if they have the appropriate access) as well as any personalized notes and highlighting they may have added. Annotations routed from other users can also be added to the receiver's personal context. Figure 14 illustrates the idea of private contexts. This concept can be extended to include additional layers, further personalizing the users information domain. The message document and private context ideas will assist the reader of this thesis to visualize the underlying organization of the system.

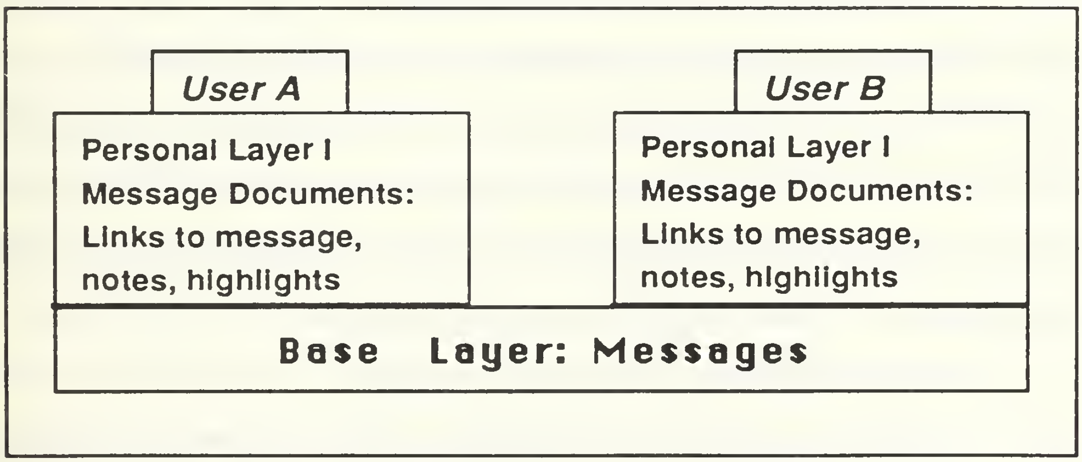

Figure 14. Private Context

E. FINDING INFORMATION: MESSAGE FILING AND RETRIEVAL

Many of the messages received have little or no long term value to the user and may not be worth retaining. Other messages may be extremely important to keep track of for future reference. With the current system the users maintain personal or office filing systems for storing these messages along with any relevant comments and annotations. It is the user's responsibility to determine the appropriate indexing title or codes to file the messages under. These personal or office files represent one of the user's most valuable and important information resources. Such files are constantly referred to when planning operations, operating/repairing equipment, submitting reports or performing a variety of other activities.

As introduced in Chapter II these paper copy files are widespread throughout the ship. Often the same message will be replicated in multiple files of a single user as well as in several different users' files. These files occupy space and represent a tremendous duplication of effort. Although no statistics were available for the quantity of message copies filed aboard ship, it is not uncommon for each of the ship's departments to have one or more filing cabinets worth of messages. The number of shipboard messages filed is substantial and requires appropriate management.

1. Personal Versus Centralized Filing

The major advantage of personal paper copy files is that their organization reflects the viewpoint of the user. These files only contain those items that the user considers important, making it faster and easier to locate and retrieve needed material. All material in a personal file system will have been reviewed at least once by the user. A central computer-based file system

on the other hand offers the following advantages (Lancaster, 1978, pp. 23-24):

- More comprehensive than personal files.
- Can provide multiple access points conveniently and economically.
- Economical use of space.
- Consistency and continuity assured.
- Nonduplicative (only filed once).

The problem with a centralized computer filing system is that it is a compromise. A general system does not reflect the specialized interests of individual users. There is no such thing as a “typical” user, each has different needs and these needs are best reflected by a system that can be personalized to some degree. It is doubtful that a central system will eliminate the need for personal files, nor is it likely that highly developed personal systems could remove the need for an effective central system.

What is needed is some way to incorporate the personal system together with the centralized one. The goal of AMHS is to provide a system where information is stored only once, but can be organized in a variety of different ways to meet the needs of a large group of diverse users. Improving the organization will allow for a more effective means of locating and retrieving information. Combining the personalized files with a centralized computer-based system will also reduce the volume of space occupied by these duplicative personal files.

The AMHS provides the capability for building personal files using the “filebox” composition mechanism introduced in Chapter IV. The filebox can be built by creating a hierarchical organization and then moving

messages into appropriate categories during the review process. An example of such a hierarchical organization might be a subject breakdown that starts with very general labels and becomes increasing specific with each level, with the lowest levels representing links to message documents. Links to message documents can be filed under multiple topic headings or fileboxes to facilitate access, and since the links are simply pointers they will not waste valuable storage space by keeping multiple copies of entire messages. Figure 15 presents an example of a filebox for the main propulsion division of a ship's engineering department.

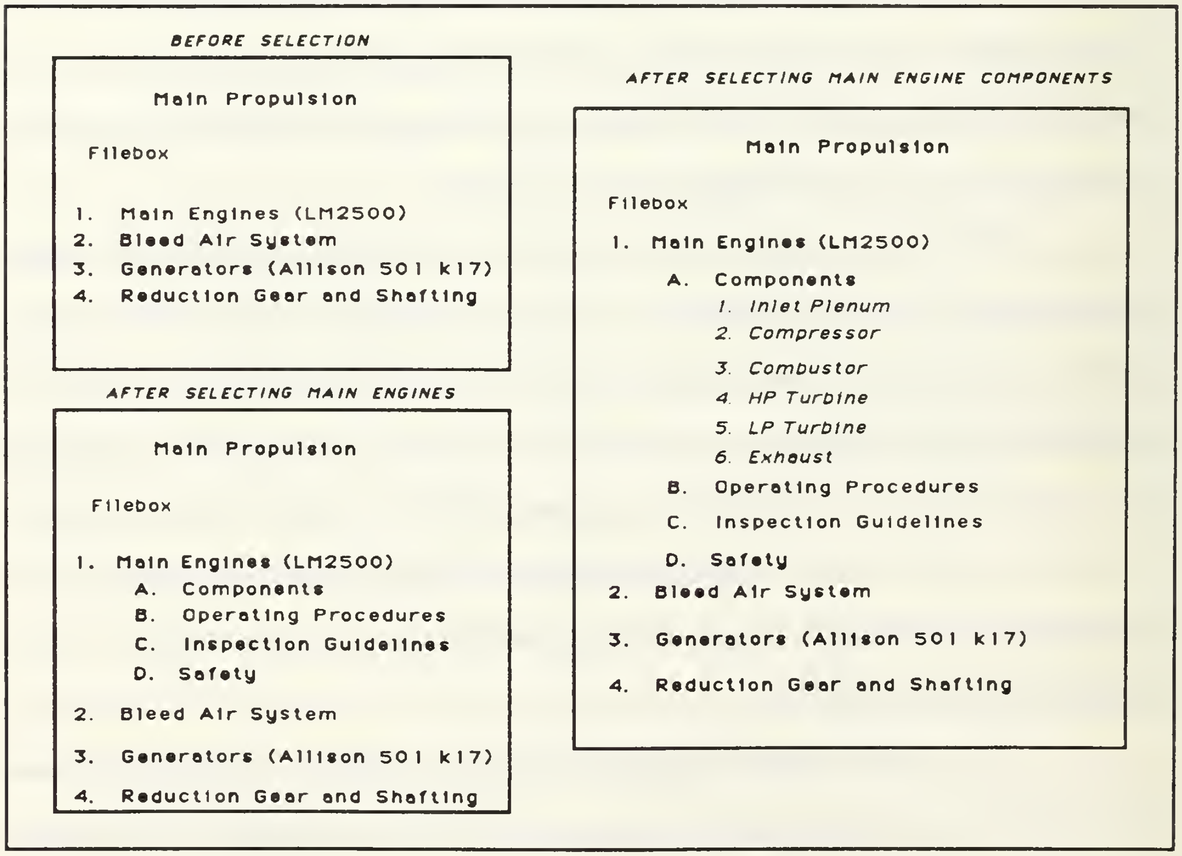

Figure 15. Filebox Organization

This sample filebox illustrates how a hierarchy can be unfolded to show lower levels. Such a feature can be implemented using a typed expansion link similar to the one that was discussed for the Guide product in Chapter IV. The third level entries in this hierarchy represent reference links that will display a listing of the messages filed under this heading when selected. Each message displayed in this list serves as a link to the user's message document for that particular message.

The concept of personalized filing provides another layer that can be added to the concept of private context. This layer, situated above the message document, allows users to customize their organizational view of the information. Figure 16 presents a more complete illustration of private contexts.

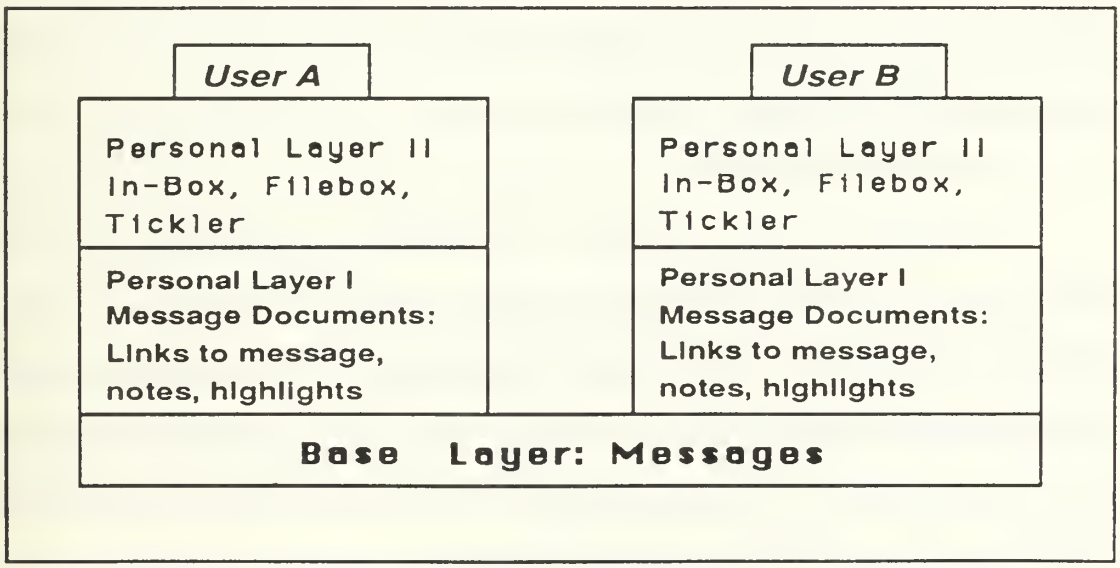

Figure 16. Two Levels of Private Context

2. Automatic Indexing

On-line indexing can be utilized to automate a portion of the message filing process. The user will establish the categories desired for indexing purposes. When a user calls up one of these indexes it will already have links to received messages for the categories specified. This is especially useful for the formatted field information of the message and may include such categories as message Date Time Group (DTG), subject, and Standard Subject Identification Code (SSIC). For each incoming message these fields will be appropriately placed in the index allowing the user to examine, for instance, a SSIC listing of his messages ordered by DTG. If a particular entry is of interest, the user can choose to follow a link directly to the message itself. More personal filing categories can be created to improve user association with the retrieval tags. Personalized user profiles can be created that would be compared against the context of the message to suggest filing alternatives. However, if the user has only a small number of categories he may choose to select the destination file(s) manually.

3. Message Disposal

A user may determine that a particular message distributed to his account is of no further interest and can be removed from the In-Box or organizational structure of the filebox. This "removal" will be accomplished by transferring the message link from its current location in the structure to a file organization in the filebox called the "Circular File." AMHS will not permit the user to actually discard links. There are several reasons for requiring the system to maintain some form of link to the message instead of breaking all ties to it. One rationale is that the existence of the link proves the message

was delivered to and reviewed by the user. Secondly, if the user determines the message is needed at a later date, he can search through the Circular-File to retrieve it, narrowing the scope of the search to messages that were distributed to the user instead of searching the entire central database.

4. Central Index

In addition to the user's personalized file organization, all messages processed by the ship will be indexed into a central system so that a command level view of the information is available. The centralized index system serves as a transaction log for all transmitted and received messages. With this system it will be possible to locate and retrieve every message received or transmitted by the ship. Users can sort the central index on a variety of identifiers to obtain a listing that fits their needs, for example ordering by SSICs to easily obtain subject category listings. The access points created for the centralized index will differ from those in personal files in that they are available as public access points. Use of the centralized index will not be restricted, but the ability to retrieve and display messages will continue to be controlled by the communications center.

5. Information Access

As was mentioned in Chapter IV, information access through index and filing structures is not always sufficient for locating information in the database. The designers of most hypertext systems have acknowledged this fact and are addressing it by providing facilities for database search and query. The AMHS will also require such facilities. The search requirements for this system will need to be slightly more sophisticated than those that were observed in the Guide and Hypercard products. Guide's search

capabilities are limited to the contents of the current document, and cannot search across links. Hypercard is slightly more powerful, but is limited to searching the cards (nodes) in the current stack (a composition mechanism used to tie cards together). These qualities severely limit the effectiveness of the search. Such a mechanism could be used to search through a pre-established index, but would not help to locate an item in the database using non-indexed specifications.

The search mechanisms for AMHS must be capable of traversing links from message document nodes as well as the organizational links present in the personal filebox arrangements. This would allow a search to be initiated at a high level in the filebox structure and reveal items of interest that were located several levels deep in the hierarchy. Similarly if a message document was searched and the information in question was located in an "attached" note, it would also be uncovered. By giving the users the capability to limit the search area to a particular filebox, or a subheading within the filebox, inquiries will be faster and have a greater probability of locating the documents that really interest the user. There may be times, however, where the user is unable to locate the desired message in his personal filing system. In this situation he may examine the central index if he knows some detailed information about the message such as its DTG or SSIC. If this information is not available a global search of the entire database using a keyword or phrase may be required to locate the message.

6. Message Archival

While message traffic represents a very valuable information resource, its worth does tend to decline over time. This does not mean that

the information received will never be needed again, but that the probability for its use will decrease with age. This does not reduce the Navy's need to adopt an improved system for handling messages, because the simple fact remains that when an old message is needed nobody wants to hear excuses for why it cannot be located. One way to handle older messages without losing access to them is to archive messages to successively less accessible storage medium on the basis of their age and activity. Though speed of retrieval will decrease, an interested user will still be able to access the message.

F. TICKLER FILE

Another user requirement of the system is the tracking of messages requiring some action to be taken or a response to be sent. The notion of keeping a file of such items, often referred to as a "tickler file", is by no means a new idea, but the automation of message distribution and review offers potential for improving the effectiveness of this tool. The tickler file will be implemented in a similar fashion to the filing system. The tickler file will serve as a composition mechanism for grouping action or response messages. When a message is presented on the screen during initial review from the In-Box or during subsequent review from the filebox the user will be presented with the option of opening the tickler file. This window will present, in tabular form, a list of the DTG, action required, and due date for the action/response messages. Selecting a message from the In-Box or filebox and moving it into the tickler file will automatically enter the message DTG and make it a reference link to the particular message document. The user can then fill in the action required and the due date. During another session the

user may decide to examine the tickler and evaluate the status of action items. The link between the entries in this table and the message documents in the hypertext database enables the user to immediately review the message along with any associated notes and highlighting. Individual and departmental tickler files can be combined to provide the commanding officer and executive officer with a unit wide report. A current listing of action messages can be of tremendous value to a command in terms of prioritizing work and reviewing commitments. The tickler provides a mechanism for accessing this information as a normal part of the message review process.

G. MESSAGE GENERATION AND ROUTING

AMHS will facilitate message generation by providing the user with templates that can be filled in with the appropriate information. A generic message blank as well as ones tailored for formatted messages such as training reports, casualty reports, and unit reports will be stored as nodes in the database. This, in and of itself, is not a significant improvement since paper format blanks already exist and some automation efforts such as NAVMACS, PCMT, and a product called MGS2 developed by NARDAC Norfolk are targeting on-line message preparation. These automation efforts will reduce labor requirements by eliminating the need for communications personnel to type messages from handwritten drafts before they can be transmitted. However, these efforts do not address the need of the majority of users who like to look at an example message when drafting a new one. They may have an automated terminal at which to draft a message, but they will still have a folder of paper messages by their side to refer to. The real advantage offered by hypertext in this area is the capability to call up a previously

processed message and have it displayed in a window on the screen at the same time the user is working on a new message in another window. Pieces of previous messages can be cut and pasted to reduce the work effort necessary and to ensure that all required information is included. A message generation window can be opened as an initial action at the beginning of a session or at any other time from the In-Box, filebox, or tickler.

Once a message has been drafted, it must be approved by appropriate personnel in the chain-of-command before it can be released for transmission. This process is referred to as "chopping the message." AMHS can assist in this process by electronically routing drafts to the accounts of those personnel that must chop the message. The message would appear in the user's In-Box with an appropriate flag to designate it as a draft outgoing message. If the user approves the draft, it can be electronically chopped and forwarded up the chain-of-command. If rejected, it can be sent back to the originator. Electronic notes can be attached and routed along with the draft, and any cited references would be immediately available for review. These features will facilitate the message approval process.

VI. CONCLUSIONS AND RECOMMENDATIONS

The proposed design for the Automated Message Handling System (AMHS) illustrates how information technology can be used to improve the efficiency and effectiveness of current shipboard procedures. During the systems analysis phase a relatively new technology, hypertext, was highlighted as the most promising alternative for enhancing user access to information while eliminating the need to distribute and store paper copies of messages. The mechanisms and features of hypertext offer exciting possibilities for automating the distribution, review, storage, retrieval and preparation of messages. Each of these processes is enhanced, eliminating many of the disadvantages of the present paper system without sacrificing the benefits.

A. BENEFITS OF HYPERTEXT

Hypertext provides capabilities that can be used to revolutionize shipboard message handling procedures. The ability to electronically link information provides the opportunity to build a system where messages can be stored in electronic form without losing any of the advantages present in the current paper-based system. While maintaining only a single physical copy, each user is given the capability of treating the message as if it was his own personal copy. Distribution of information to users is accomplished by routing electronic links. This saves storage space, ensures message integrity and provides increased access control. Messages can be annotated, highlighted and organized to reflect the individual views of users without requiring redundant storage or interfering with the views of others. The system provides access to

complete information by grouping related items, permitting users who want information on a particular topic area to access all messages, references and notes that are relevant without having to search each item individually. Use of such a technology enables the Navy to significantly improve the shipboard message handling process instead of simply duplicating the current system electronically.

B. SUPPORT OF DESIGN PRINCIPLES

Typically when a process is automated important questions arise concerning how the new system will deal with existing policies and traditions. A set of principles and design issues was developed during the systems analysis phase to ensure that the AMHS design is compatible with Navy policies. These principles include maintaining the integrity and security of messages, ensuring quick and easy retrieval, controlling access, and providing flexibility and ease of use. Hypertext enables the proposed system to support each of these principles.

C. RECOMMENDATIONS

The result of adhering to these principles is a design for the AMHS that is consistent with the Navy's current policies and trends to improve shipboard message handling procedures. The proposed system supports the objectives of the "paperless" ship initiative by reducing the requirements for paper aboard ship and making the information contained in message traffic more accessible and easier to use. The design for the AMHS can be readily adapted to fit ongoing Navy automation efforts. AMHS is capable of filling the role of the office automation system described in the NAVMACS/PCMT plan to

modernize the communications center/user interface. Another alternative would be to develop AMHS as a direct interface between the users and the communications center.

Advancements in computer technology make it feasible to implement the proposed system on currently available, low cost, commercial hardware. The prototyping efforts used during the design process support this point. The software technology necessary to develop AMHS is also available. While no single hypertext product offers all of the features identified during the analysis and design, the capability exists to build such a system using contemporary tools and techniques.

Naval messages represent a vital shipboard information resource. The benefits offered by hypertext for improving the handling and use of this resource aboard ship make this technology worthy of further investigation. It is recommended that the logical design for the AMHS be rapidly prototyped to a more detailed level and tested aboard ship to determine its usefulness as an information management tool.

The benefits of hypertext can be broadly applied to many shipboard automation efforts. This thesis has demonstrated that hypertext has potential for enhancing the usefulness of working materials. These items are especially important because they are used on a daily basis and represent the most current and up-to-date information available on the ship. While this paper has focused on messages, other materials that might benefit from further investigation include administrative files; personnel, training, and maintenance records; and stock and requisition reports.

The opportunity exists to use information technologies, such as hypertext, to tie these currently separate pools of information together. The concept of electronically linking logically related items would enable users to have comprehensive access to information across such resources as messages, instructions, technical manuals and administrative files. The capability to access material in this manner would greatly improve the effectiveness of existing information assets. It is not necessary to design this as one all-encompassing system as long as a standard format is used in the development of the databases. Such an approach not only allows portions of the system to be built incrementally, but also increases the portability of the design to other hardware configurations. As systems are developed they can be tied to each other using the electronic links that characterize hypertext.

Information is becoming an increasingly important resource in today's Navy. Properly managed this resource can be a force multiplier to offset shortfalls in other areas, however in its current paper format it tends to create additional burdens on the personnel who must use and maintain it. Hypertext offers promising alternatives for improving user access to information which is stored in an electronic form. It is strongly recommended that the Navy investigate the potential for this technology to support the "paperless" ship initiative, taking a broad view of the application areas that might benefit from its use.

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